



This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

- + *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.
- + *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.
- + *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.
- + *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at <http://books.google.com/>

UC-NRLF



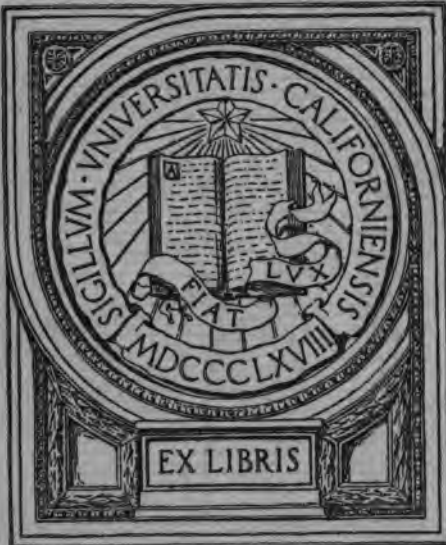
5B 78 040

THE
CYANIDE PROCESS
FOR THE
EXTRACTION OF GOLD



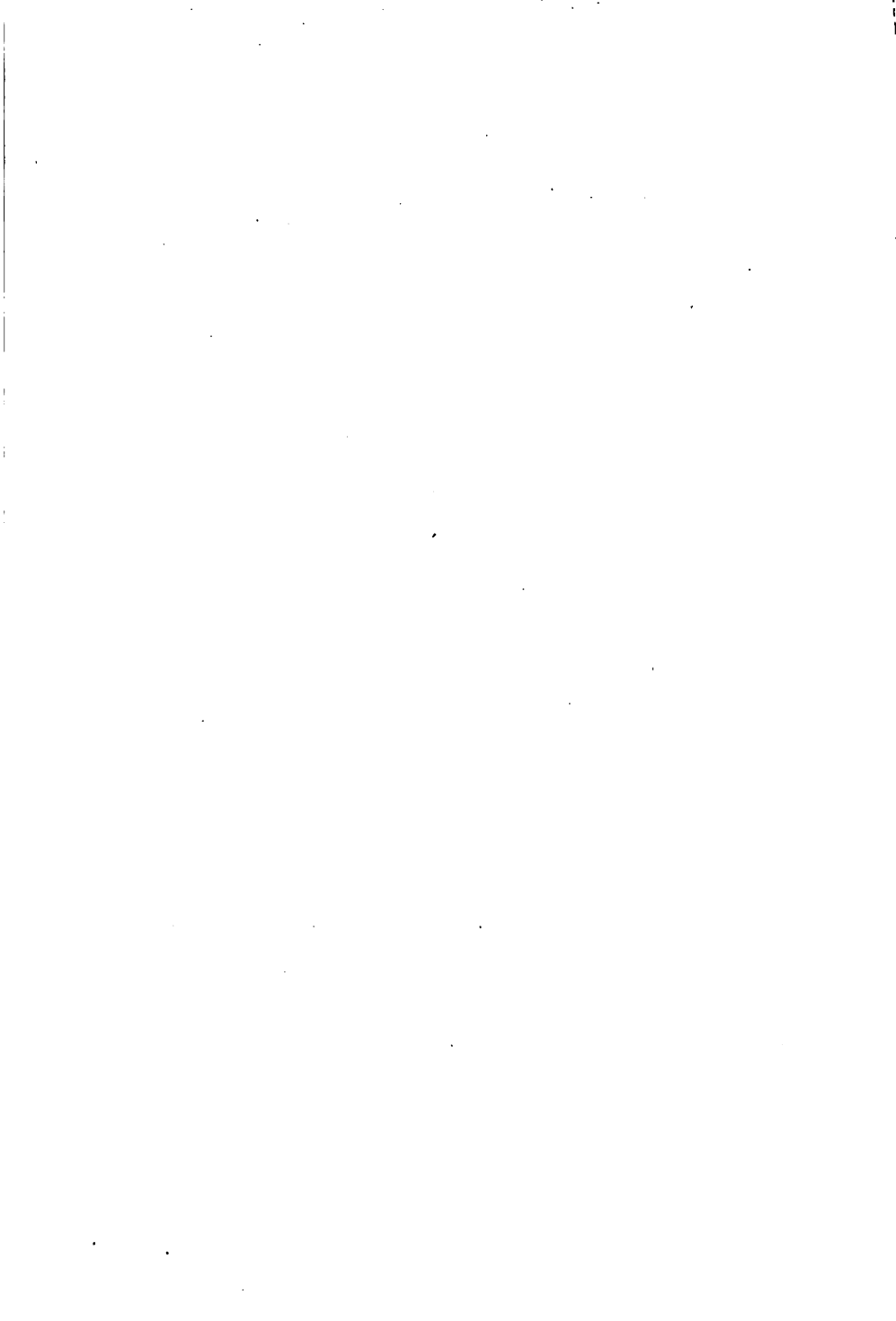
M. EISSLER

IN MEMORIAM
FLORIAN CAJORI



EX LIBRIS





Alonso Cajon.
1895.

THE
CYANIDE PROCESS
FOR THE
EXTRACTION OF GOLD

BY THE SAME AUTHOR.

THE METALLURGY OF GOLD: A Practical Treatise on the Metallurgical Treatment of Gold-bearing Ores. Including the Processes of Concentration and Chlorination, and the Assaying, Melting, and Refining of Gold. Third Edition, greatly Enlarged. With 187 Illustrations. Crown 8vo, 12s. 6d. cloth.

"The whole process of gold milling, from the breaking of the quartz to the assay of the bullion, is described in clear and orderly narrative and with much, but not too much, fulness of detail."—*Saturday Review*.

THE METALLURGY OF SILVER: A Practical Treatise on the Amalgamation, Roasting, and Lixiviation of Silver Ores. Including the Assaying, Melting, and Refining of Silver Bullion. Second Edition, Enlarged. With 150 Illustrations. Crown 8vo, 10s. 6d. cloth.

"From first to last thoroughly sound and reliable."—*Colliery Guardian*.

THE METALLURGY OF ARGENTIFEROUS LEAD: A Practical Treatise on the Smelting of Silver-Lead Ores and the Refining of Lead Bullion. Crown 8vo, 400 pp., with 183 Illustrations, 12s. 6d. cloth.

"The numerous metallurgical processes, which are here fully treated of, embrace all the stages experienced in the passage of the lead from the various natural states to its issue as an article of commerce."—*Practical Engineer*.

A HANDBOOK ON MODERN EXPLOSIVES: Being a Practical Treatise on the Manufacture and Application of Dynamite, Gun-cotton, Nitro-glycerine, and other Explosive Compounds. With about 100 Illustrations. Crown 8vo, 10s. 6d. cloth.

"Useful not only to the miner, but also to officers of both services to whom blasting and the use of explosives generally may at any time become a necessary auxiliary."—*Nature*.

LONDON: CROSBY LOCKWOOD & SON.

THE
CYANIDE PROCESS
FOR THE
EXTRACTION OF GOLD
AND
*ITS PRACTICAL APPLICATION ON THE
WITWATERSRAND GOLD FIELDS
IN SOUTH AFRICA*

BY
M. EISSLER
MINING ENGINEER; A.I.M.E.; MEMBER OF THE INSTITUTE OF MINING AND METALLURGY
AUTHOR OF "THE METALLURGY OF GOLD," ETC., ETC.



LONDON
CROSBY LOCKWOOD AND SON
7, STATIONERS' HALL COURT, LUDGATE HILL
1895
[All rights reserved]

M304871

TAYLOR
EST

INTRODUCTION.

IT is a great satisfaction to me to be in a position to place before the public, in the present volume, an account of the Extraction of Gold by the Cyanide Process, which I believe will be found by Metallurgists who desire to avail themselves of the process to be sufficiently full and complete for practical purposes. That I am in a position to do this, is owing to the fact of my having made a lengthened stay in the Witwatersrand gold fields — whence I have just returned—and to my having enjoyed there unique opportunities of studying the process in actual operation.

Before entering upon an account of the process, some further introductory remarks will be advisable.

Metallurgy, as applied to preparing and winning the gold from its ores, resolves itself, broadly speaking, into two methods, in one of which mechanical

means, and in the other chemical means, are employed. I consider the stamping or crushing of the ore in a battery, and the catching of the gold on amalgamated copper plates, a mechanical process, although the recovery of the gold in chemical combination with mercury might entitle it to be considered otherwise. The whole process is nothing more or less than a simple system of concentration, as the gold, owing to its great specific gravity, separates from the lighter gangue in which it is enclosed; and when the pulverized ore particles are washed away, the gold grains sink and are arrested on the amalgamated smooth surfaces of the plates over which the stream carries them, or get entangled in the hairs of the blankets, or are stopped in the riffles of the sluice box, or whatever other method is used in the battery to save the free gold.

When gold is in combination with other minerals, more complicated methods have to be employed to collect it by mechanical means, but these it will be unnecessary to describe in the following pages.

There are very few chemical means by which gold can be won from its ores, leaving aside the smelting process by which the gold is collected in the smelting furnace by means of, and in combination

with, other metals. The reason why gold is not easily won by chemical means is because it is a non-oxidizable metal, which maintains its purity, and is therefore mostly found in its native or metallic state. Owing to its rarity it has become of such great value, and the medium of interchange since the remotest times.

Its solvents are aqua regia, chlorine, and potassium cyanide. The application of such a corrosive agent as aqua regia for the treatment of ores on a large scale is out of the question, and of the chemical means at our command there remain only the last two. By exposing the gold ores, or the concentrated portion of the same, to the action of chlorine gas, the gold is converted into a soluble chloride of gold by the well-known chlorination methods; and by the other method the gold is dissolved in solutions of cyanide of potassium.

That gold when in a fine state of division was soluble in cyanide of potassium, was already known in the middle ages, and the gilding of metals was carried out in those remote days by jewellers and alchemists, by the use of gold in cyanide solutions. Of course, gilding by means of fire was usually employed.

Several scientific books, dating back to the beginning of this century, mention the solubility of gold in potassium cyanide solutions. The application of this solvent for the treatment of auriferous ores was first thought of and patented in the United States in 1867 ; and although the process was tried and experimented with by some eminent metallurgists of that country, no practical or commercial results were obtained.

Now, how is it—in spite of repeated failure in America and elsewhere—that within the last few years the cyanide process has come into such pre-eminence, and as such a grand success, before the metallurgical world ?

In answer to this question, I believe I am safe in stating that the ores of the Witwatersrand gold fields, where the cyanide process was first introduced, carry the gold in a pure and metallic state, in an extremely fine state of division (and even in the pyrites, the gold does not occur in chemical combination, but in a free state) ; and, therefore, all the conditions existed there to make the application of the cyanide process a perfect success. These facts are not only of interest to the metallurgist, but they should also throw some light on the geological features and conditions under which these peculiar conglomerate beds were formed.

The mines of this district, it should be said, will for ever have to acknowledge the immense services which the MacArthur-Forrest Company have rendered by developing and introducing the process, as they spent large sums to bring it into practical shape, and to demonstrate its commercial advantages. But for those exertions, enormous values would have remained practically unavailable, preventing many mines from working at a profit, and the production of these fields would not be what it is to-day by 50 per cent.

In this connection I can mention that out of a total gold production of 1,478,470 oz. in 1893, there were produced from the tailings 330,510 oz. by the cyanide process; and in August, 1894, out of the monthly production of 174,977 oz., nearly 58,000 oz. were won by the cyanide process.

The great future and potentiality of development which may be anticipated for these gold fields is strikingly illustrated by the opinion of such an eminent authority as Mr. Hamilton Smith, who (in his report to the house of N. M. Rothschild & Sons), has stated that that portion of the Witwatersrand which lies between the Langlaagte Block B and the Glencairn Mine—or about $11\frac{1}{2}$ miles in length, along the strike of the main reef series,—if exploited to a verti-

cal depth of 3,000 ft., would yield in gold 215 million pounds sterling; while Bergrath Schmeisser (in his report made to the German Government), taking for estimate a depth of 800 metres, arrives at the yield of 208 million pounds, and for a depth of 1,200 metres, the yield of 349 millions. And when we consider that at least one-third of these prodigious amounts will be won by the cyanide process, one can hardly overestimate the importance of the work which the MacArthur-Forrest Company has done in bringing that process into its present position of prominence in the Witwatersrand gold fields. Certainly it cannot be gainsaid that they are entitled to a fair reward for their labours.

When I arrived in 1890 on the Witwatersrand gold fields, I undertook numerous experiments for the treatment of tailings by pan amalgamation, but with unsatisfactory results. The difficulty I had to contend with was the formation of large quantities of iron amalgam in the pan. The quicksilver became dirty and floured, causing very heavy losses, and I had a costly process before me to separate the iron from the gold; and although others followed me, and put up various devices for treating the tailings, it was only the advent of the cyanide process which solved this

most difficult problem, as pan amalgamation would have been too expensive.

So far, the process has not achieved similar success in other countries, which to my mind proves that the ores on these fields contain the gold in a free condition; and to further corroborate this view, I can state that at the Simmer and Jack mine the pyritic concentrates which are daily collected on the blankets yield by pan amalgamation 65 per cent. Of course these blanketings contain a considerable amount of free gold which escapes from the copper plates.

Within the last few months, Messrs. Siemens and Halske have successfully introduced on the same fields their patented process, which consists in precipitating the gold by electricity on sheets of lead; and, owing to certain economical advantages, it may be anticipated that their process will prove a formidable rival to its predecessor. In the succeeding chapters will be found an account of the working details of these processes, including some of the observations and researches of those gentlemen who have been most prominent in bringing them to their present state of perfection.

I must not conclude these remarks without expressing my deep obligations to the several gentlemen—

whose names will be found duly recorded in the following pages—to whom I am indebted for much of the material and information embodied in the volume, and for the opportunities so freely afforded me, during my stay in the Witwatersrand gold fields, of making myself practically acquainted with the working of the cyanide process. It is not myself only, but all who are interested—whether as metallurgists or investors—in the gold-mining industry, who have thus been laid under obligation; and as I have taken no small pains to put to good use the material and opportunities which have been so freely placed at my disposal, I trust that the outcome of my efforts in the present volume will prove thoroughly acceptable to that numerous body.

37, BELSIZE PARK,
SOUTH HAMPSTEAD, LONDON, N.W.
December, 1894.

CONTENTS.



CHAPTER I.

	PAGE
ERECTION OF A CYANIDE PLANT	I

CHAPTER II.

EXTRACTION BY CYANIDE	23
---------------------------------	----

CHAPTER III.

THE SIEMENS-HALSKE PROCESS	40
--------------------------------------	----

CHAPTER IV.

PARTICULARS OF OPERATIONS AT VARIOUS WORKS	57
--	----

CHAPTER V.

THE CHEMISTRY OF THE CYANIDE PROCESS	69
--	----

INDEX	91
-----------------	----

LIST OF ILLUSTRATIONS.

FIG.		PAGE
1.	(PLATE I.) SECTION OF PRINCESS WORKS . . . <i>facing</i>	4
2, 3.	(PLATE II.) MESSRS. BUTTERS AND MEIN'S AUTOMATIC DISTRIBUTOR <i>facing</i>	8
4, 5.	Do. Do. (SIZE A)	9
	PORTRAIT OF MR. CHARLES BUTTERS <i>facing</i>	12
6.	(PLATE III.) TAILING WHEEL, VANNER ROOM, AND CYANIDE VATS AT THE JUMPERS MINE <i>facing</i>	14
7.	STAVES CUT TO CIRCLE	15
8.	CONSTRUCTION OF FILTER VATS	16
9.	(PLATE IV.) STONE FOUNDATION FOR FILTER VATS <i>facing</i>	16
10.	SOLUTION PIPES	17
11, 12.	BUTTERS' DISCHARGE LID	19
13.	ZINC PRECIPITATION BOX	21
14.	(PLATE V.) THE WORCESTER CYANIDE PLANT . <i>facing</i>	42
15.	(PLATE VI.) Do. Do. „	44
16, 17, 18.	(PLATE VII.) DEPOSITING BOX „	46
19.	(PLATE VIII.) GENERAL VIEW OF THE SIMMER AND JACK CYANIDE PLANT. <i>facing</i>	62
20.	(PLATE IX.) SIMMER AND JACK FILTER VATS „	62
21, 22.	(PLATE X.) SIMMER AND JACK EXTRACTOR HOUSE „	64
23.	(PLATE XI.) CENTRAL WORKS OF THE RAND CENTRAL ORE REDUCTION COMPANY <i>facing</i>	68

THE
CYANIDE PROCESS
FOR THE
EXTRACTION OF GOLD.

CHAPTER I.

ERECTION OF A CYANIDE PLANT.

Planning the Works.—In the erection of a cyanide plant, before planning the same, some essential points have to be considered. Are the works to be erected to treat an old accumulated stock of tailings? Or have they to be laid out to treat the tailings as they come from the battery? In many cases both these points have to be combined.

As tailings reservoirs are generally situated on the lowest point below the battery site, no provision exists below such dams for the erection of works which would permit of further dumping-ground and handling of the stuff by gravitation. At all events, the topographical conditions of Witwatersrand would allow such an arrangement only in rare instances. In localities where the fall of the ground below the reservoirs permits of the erection of the works, I would recommend this to be done, as it permits of the charging of tanks and their discharging by gravitation. In most cases the opposite course had to be resorted to on these fields; the tailings from the old pits or reservoirs had to be hauled up-hill to the cyanide works, steam power being mostly used. The arrangement is simple enough, as the dumping cars are pulled up on an inclined trestle-work above

the leaching tanks, and after discharging their contents they run back by gravitation, and are held back by the brake of the hauling drum. In large works five to six trucks, holding 20 cubic feet each, are hauled up at a time. At every mine the mechanical arrangement for the filling of the tanks is different, depending on local conditions. Messrs. Fraser and Chalmers have lately introduced a system of mechanical haulage by means of endless wire ropes which works very well, and which I would recommend in preference to anything I have seen on these fields.

To work old tailings by the cyanide process offers no difficulty to percolation, as they come to the works in the proper condition. They were cleaned of the slimes by the natural system of concentration, which takes place in the collecting reservoirs. It is very interesting to stand at the discharge end of the launder carrying the tailings to the reservoir, and to see how the tailings arrange themselves according to the natural laws of gravitation, and are prepared here for subsequent treatment. At the head of the tailing pit the coarser tailings accumulate, and near the dam the finest, and also slimes. The overflow from the first reservoir is collected in a second reservoir, where the slimy, clayey residue accumulates, which, strange to say, is as rich, and even richer, than the tailings in the first reservoir.

To lay out plans for an accumulated stock of tailings offers no great difficulty, provided there is near by a sloping ground permitting of the discharging from the leaching tanks and their dumping by gravitation. If the country is flat, the re-worked tailings will have to be hauled up an incline again and then dumped. On a flat site it will be necessary to place the leaching vats on masonry sufficiently high to give room for discharge, and gradient for the flow of the leaching solutions to the precipitation boxes.

When works are erected to treat tailings which are discharged from the battery, important appliances have to be resorted to, to prepare them for the cyanide treatment, and before they are collected in the leaching vats, owing to the physical condition of the powdered ore.

The discharge launder which carries the tailings from the battery to the cyanide works should have a grade of at least 3 ft. 6 in. in the 100 ft. to insure a good flow. In a flat country where no grade exists, the tailings should be elevated by means of bucket wheels to the proper height. From the experience gained on these fields, tailing pumps have not given satisfaction; it may be that they were not properly constructed, as I am told that in Australia they are in various places in successful operation. There are on several mines here large tailing wheels in use, and I should consider them the best way of elevating tailings, as they require very little attention and repairs when properly constructed and set.

Supposing that we desire to erect a cyanide plant directly behind a battery, the following grade would be required for doing the whole work by gravitation. Supposing the plant to be located 100 ft. from the battery—

	Feet. Inches.	
The grade for the discharge launders will require	3	6
Masonry for settling tanks	6	6
Settling tanks	10	0
Masonry for leaching tanks	6	6
Settling tanks	10	0
Precipitating boxes and grade for outflow pipes	6	0
Total grade	42	6

To this could be added from 6 to 10 ft. of grade for the storage tanks holding the cyanide solutions, wash and alkaline waters, but these are differently placed, and a lack of further grade would present no difficulties, as will be explained later on.

Fig 1 (Plate I.), showing a section of the cyanide plant of the Princess works, illustrates such a mode of arrangement as is here described.

Slimes.—The conglomerates on these fields, after stamping, contain a very large per cent. of slimes. Under slimes are understood the very fine particles of talcose and clayey material mixed with the very fine grains of quartz, iron oxides, and sulphides. If the whole of this fine material be allowed to collect

with the coarser grains, the percolation of fluids through the mass becomes impossible, and, therefore, mechanical means have to be adopted, aiming at a separation of the slimes from the coarser material.

Two methods have been introduced on these fields, aiming at the elimination of the slimes. The one by *direct filling* is the system introduced by Mr. Henning Jennings, the well known mining engineer; and the other *the intermediate filling* adopted by Mr. Charles Butters and Captain Mein, the manager of the Robinson mine.

I will take occasion to remark here that the appliances for the plant were materially changed by Mr. Charles Butters, who has done a great deal for the advancement of the metallurgical treatment of the ores on these fields, as he has introduced a great many practical details, all tending to lessen the cost of the process, and I consider it a very pleasant duty on my part to express my appreciation of his labours and of the good he has done by his work.

The elimination of the slimes has an economic bearing on the gold mining industry of these fields, when it is considered that at least 30 per cent. of the Witwatersrand ores, after crushing, pass away into slime pits: therefore, at the present production of 250,000 tons of ore per month, 75,000 tons go into the slime pits. At the present rate of progress it is almost certain that the tonnage will increase to nearly double this amount, and that within three years the Witwatersrand will be producing 300,000 ounces of gold or one million sterling monthly. If we take the average value of the slimes all around at only 5 dwts. per ton, this represents nearly 20,000 ounces of gold which goes into the pits monthly.

Up to the present no cheap method has been devised to deal with the slimes, so as to win the gold from them at a profit. The question of treating the slimes successfully is simply a mechanical one, as there is no chemical difficulty in the way: on the contrary, the solution of the gold can be easily effected, owing to the fine state of division in which the gold exists in the slimes.



My impression is that the eventual solution of the problem will be a system of agitation in vats fitted with mechanical stirrers, and after agitation and settling the solution will be decanted and a weaker solution added again, again stirred and decanted, till the last wash waters will only show traces of gold. This method will become applicable owing to the introduction of the Siemens and Halske process, which effects the precipitation of the gold from the extreme weak solutions which will have to be used. A successful solution of this problem will add largely to the gold production of the fields.

The Effect of Stamping on the Ore.—When ores are stamped in a battery, the resulting product is very uneven, and this is one of the recognised disadvantages of the batteries in use in all gold countries.

The majority of the mines on these fields crush fine, using mostly screens of 900 mesh per square inch, and about 50 per cent. of the ore is converted into slimes. To illustrate the fineness to which stamping reduces the ore I may mention that Mr. Williams, the metallurgist of the Crown Reef mine, informed me that the slimes which flow into their pits do not settle in 24 hours, and that if the overflow is taken and allowed to settle, these second settlings will assay 6 dwts. per ton, being richer, therefore, than the first settlings. He further stated that after the water leaves the second slime pit it still holds in suspension 2 per cent. of the total gold contained in the ore as it comes from the mine. This is the result from careful experiments and trials. In regard to the difficulty of settling the fine slimes which remain in suspension, it was ascertained at the Paarl Central works, that the overflow from a large tailing dam carried 8 per cent. of the rock crushed in suspension. As the water on these fields does not run to waste, but is used over and over again in the batteries, there is really no loss incurred, as the suspended slimes eventually settle, the water only retaining a certain constant portion.

To give a further illustration of the effects of stamping on

the Witwatersrand conglomerates, I will furnish some figures communicated to me by Mr. Bettel, a gentleman whose name has also been closely connected with the cyanide process.

40 lbs. of tailings were caught at a battery in a tub, and at least 30 per cent. passed away as slimes, the ore coming through a 900 mesh screen. After drying, it was sifted through a screen of 1,600 mesh per square inch, and there remained on the sieve 1·85 per cent. (1)

It passed afterwards through three sieves as follows :

3,600 mesh and there remained on the sieve	27·93 per cent.	(2)
7,225 " " " "	20·74 "	(3)
14,400 " " " "	7·70 "	(4)

The sands passing the last sieve were panned, and

A. Remaining in the dish represented .	11·80 per cent.	(5)
B. Finest sand panned away .	22·34 "	(6)
C. Slimes collected from the panning water .	7·64 "	(7)
Total .	100·00	

Each of these grades was assayed, with the following results—

1	. . . . .	3·03 dwts. per ton.
2	. . . . .	4·00 " "
3	. . . . .	4·40 " "
4	. . . . .	4·65 " "
5	. . . . .	6·30 " "
6	. . . . .	2·85 " "
7	. . . . .	2·85 " "

These figures are very instructive, as they show how very fine the ore is crushed in a battery, and that the material, after passing through a 120 mesh sieve per linear inch, can be concentrated, and will yield a concentrate of over double the value of the sands washed away. No doubt the practical part of these figures will be very soon appreciated on these fields when concentration will receive closer attention than it does at present.

After this notice of the important part which the slimes

play in the metallurgy of the Rand gold fields, I will revert again to the planning of the works.

The Plant.—The main features of a cyanide plant are the settling vats, the filter vats, the solution storage tanks, and the precipitation-boxes.

The filter vats are made of timber, or they are brick vats lined with cement. At the Langlaagte Estate and Gold Mining Company, circular excavations were made in the rocky ground, lined with bricks and cemented, forming tanks 40 ft. in diameter and 10 ft. deep, each holding 400 tons of tailings.

Filter vats made of timber will last for years, as contact with cyanide solutions does not seem to destroy it.

I have not been able to obtain the cost of a plant constructed in masonry, but I should consider it more expensive than the timber plant. Where wooden tanks are in use they are placed in such a position that free access can be had to the bottoms in case of leakage, which is an advantage.

The number of filtering vats required for a plant depends on the capacity of the battery, and the time it takes to treat a charge of ore. If we want to treat 100 tons of tailings daily, and it takes, say, 3 days to fill, leach, and discharge a vat, it will require 4 leaching vats of 100 tons capacity each (dimensions 22 ft. in diameter and 5 ft. high), but for safety one extra tank is added. The tendency on these fields is to construct a few large vats for the plant, instead of a large number of small ones. As long as shallow vats were employed, there was no difficulty in shovelling out the tailings over the sides; but with deep vats the bottom discharge was introduced by Mr. Butters. Before the tailings go to the leaching tanks they have to be freed of their slimes, and I shall now describe the two methods adopted for this purpose.

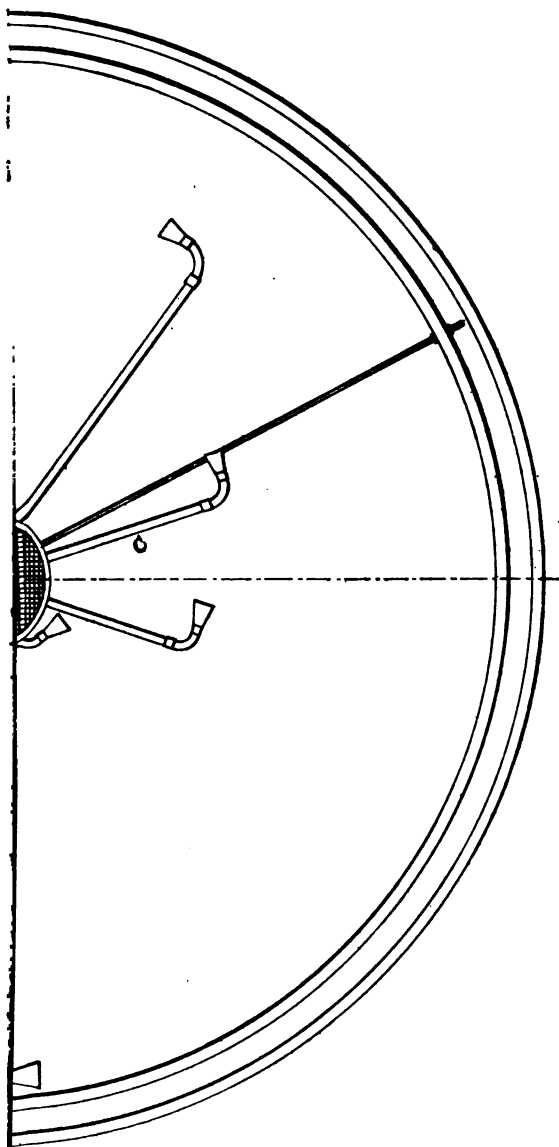
Intermediate Filling. Messrs. Butters and Mein's Distributors.—The first attempts at intermediate filling were made by running the battery tailings to the centre of a circular

vat, and allowing the overflow to take place at one point. This did not prove successful, because the sand piled up in a central conical heap, and the slimes settled in the deeper water around the sides of the tank. The next plan was to run the pulp into the vat through a series of stationary launders, delivering at several fixed points. This method improved the distribution, but the result was still unsatisfactory. Then, in order to give an uniform overflow at every point of the periphery of the vat, a circular trough was fixed round the top to collect the overflow and deliver it to a launder.

Each of these alterations was a step in the right direction, but the system of settling could not be considered successful until after the introduction of an automatic revolving distributor. This appliance consists of a central casting, with a vertical spindle A revolving in a footstep bearing B, which casting carried a conical hopper E and a number of radial pipes C with bent ends, as shown in section in Figs. 2, 3 (Plate II.), and 4 and 5.

The distributor is fixed on an iron column in the centre of the vat. The bends at the end of the pipes cause the apparatus to revolve by the reaction of the pulp as it leaves the pipes. Each pipe has a different length, in order to distribute over a number of concentric circles. This also has its faults, as it was found that the slimes collected in narrow rings between the outlets of each pipe, giving rings of clean sand alternately with rings of slime. The difficulty was overcome by attaching flattened nozzles to the ends of the pipes, causing the pulp to spread over a wider area, and also by increasing the number of pipes.

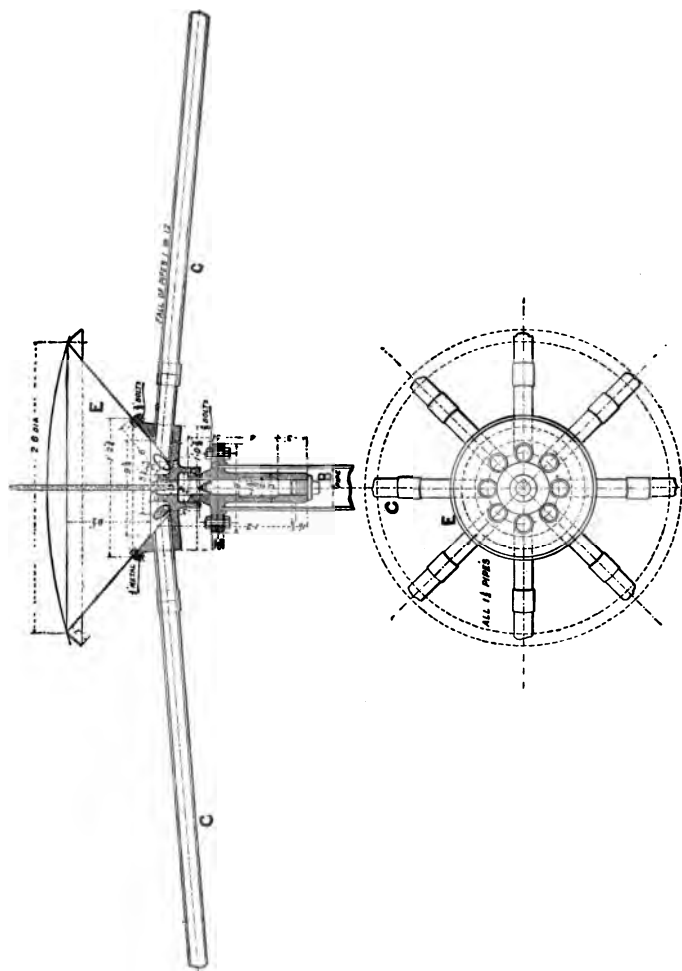
As is noticed by this plan, the arrangement is a hemispherical bowl from which radiate 8, 12, to 16 pieces of pipes of various length, which is set in motion by the centrifugal action of the discharging water, something similar to a garden sprinkler, only that it revolves slowly. The bowl is covered with a coarse screen so as to prevent chips or leaves to enter and choke the pipes. The diameter of the discharge pipes is $1\frac{1}{2}$ to $2\frac{1}{2}$ in.



Figs. 2 and 3.—Messrs. Butters and Mein's Automatic Distributor.

[To face p. 8.]





FIGS. 4 AND 5.—MESSRS. BUTTERS AND MEIN'S AUTOMATIC DISTRIBUTOR (SIZE A).

It is necessary to fill the vat with clean water before admitting the pulp. If this is not done, the water is practically stationary, and a constant settlement of slimes takes place until the vat is full and the overflow begins, in which case the tailings in the lower part of the vat will always be more slimy than those in the upper part. For the same reason it is essential that the overflow be continuous until the vat is full of sand; for if any stoppage takes place slime settlement in excess occurs, and a complete layer of slime is formed across the vat which prevents the overlying sand from draining dry. Therefore, when the battery is stopped, an equal quantity of water should be supplied to the vat. When the pulp is admitted into the tank previously filled with water, the light slime remains in suspension and overflows into the annular ring which surrounds the tank at the top, and from the discharge opening is carried by a launder to the slime-pit.

When the vat is filled with tailings, the outlet pipe below the filter is opened and the water allowed to drain off, the draining taking about fifteen to twenty-four hours. When holes are dug down to the discharge doors, water again commences to flow from the outlet, consequently it is advantageous to dig these holes about six hours before the discharging.

One very important matter is the proper size of vat to be used for a given tonnage crushed in the battery. It is, of course, desirable to catch as large a quantity of slimes with the sands in the tailings as is possible without rendering the product unleachable. When the vats are too small they carry away too much fine sand with the slime; and if they are too large they catch too much slime, which settles in excess. The great difficulty to overcome yet with these intermediate vats is to get the last foot or two near the bottom properly drained, and if discharged and transferred to the leaching tanks in this wet condition, the excess of moisture dilutes the cyanide solution.

To facilitate and hasten the leaching, various devices have been adopted. At the Princess works, where the ground is steep, the drainage pipe has been extended down to the reser-

voir, thereby causing a natural suction. At the Simmer and Jack works the drainage pipe is connected with a steam exhaust acting like an ejector, so as to cause a vacuum below the filter, and thereby the rate of leaching is increased. At the Worcester works the vats catch from the crushed ore from 75 to 80 per cent. of good leachable tailings, containing 12 per cent. moisture after draining eighteen to twenty-four hours.

The following are the sizes of the intermediate vats erected at some of the works :—

Meyer and Charlton Gold Mining Company, treating 120 tons per day, has 4 vats, each 20 ft. in diameter and 8 foot staves.

Pioneer Gold Mining Company, treating 70 tons daily, has 2 vats, each 20 ft. in diameter, and 14 foot staves.

Worcester Gold Mining Company, treating 70 tons daily, has 2 vats, each 20 ft. in diameter, and 8 foot staves.

Princess Gold Mining Company, treating 85 tons daily, has 2 vats, each 20 ft. in diameter, and 7 foot staves.

The Robinson Gold Mining Company, treating 330 tons per day, has 6 vats, each 24 ft. in diameter, and 11 foot staves.

When all the pulp is running into 1 vat, only about 66 per cent. of the crushed ore is caught, but the whole of this is clean sand and drains sufficiently. If, however, the total pulp from the battery was run into 2 vats, about 80 per cent. of the crushed ore, instead of 66 per cent., would be obtained from the distributing tank. After the water has been leached out, the ore is discharged through bottom discharges into trucks and taken to the leaching tanks. In some localities the distributing tanks are on a higher level than the leaching tanks, and the trucks are then run by gravitation to the leaching tanks. At some works the distributing tanks are at lower level than the leaching tanks, and then the trucks have to be hauled up by steam power.

The framework of the tram lines on which the trucks are hauled up to the leaching tanks rests inside the tanks and on the masonry foundation, and at large works there is generally a

double line of rails on top of the tanks. The vats and storage tanks are in the open, and not covered by a building.

The following are the advantages of intermediate filling, as introduced by Mr. Charles Butters* :—

1. It is claimed that, by means of Mr. Butters' distributor, from 75 to 80 per cent. of sands, both coarse and fine, with some slimes, are collected in the intermediate tanks, the bulk of the slimes escaping with the effluent water, which is practically free from sands.

2. The water is drained off as near as possible, and when the intermediate vat is discharged through the bottom discharges, the sands during the operation get thoroughly mixed up, thus being in the best condition for treatment by cyanide.

3. Oxidation of pyrites is very slight, so that very little cyanide will be consumed.

To an impartial observer it would appear that the system of intermediate filling would commend itself as the one which is more practical, as the tailings undergo, so to say, a special preparation for the subsequent lixiviation. The expense of transferring the tailings from the intermediate tank to the leaching tank is so slight that it cannot be considered as an important item.

The cost of charging tailings and discharging the residues has been brought down at the Robinson Mine to 10d. per ton of 2,000 lbs., and generally stands in the accounts of other works at about 1s.

Messrs. Butters & Mein's Distributors are constructed in three sizes according to the following particulars :—

Size A Distributor has 8 distributing pipes, all of $1\frac{1}{2}$ in. diameter, and is the size of distributor used on batteries up to 30 stamps.

* The position held by this gentleman in the Witwatersrand gold fields is so influential, that the accompanying portrait will be of great interest to many readers of this book ; and I have great pleasure in inserting it here, if only to emphasise my sense of the acknowledgment due to Mr. Butters in regard to the information and assistance so freely afforded to me when collecting materials for this volume.—M. E.



MR. CHARLES BUTTERS.

[To face p. 12.]

Size B has 12 distributing pipes—6 of 2 in. diameter, 2 of $1\frac{1}{2}$ in. diameter, and 4 of $1\frac{1}{4}$ in. diameter—and is the size of distributor used on batteries of from 30 to 70 stamps.

Size C has 16 distributing pipes—2 of $2\frac{1}{2}$ in. diameter, and 14 of 2 in. diameter—and is the size of distributor used on batteries of from 60 to 120 stamps.

The above sizes of distributors have been calculated on the average crushings per stamp for the Rand.

Direct Filling.—This method, introduced at the works of the Heriot, City and Suburban, Crown Reef, Paarl Central, and Geldenhuis Estate companies, consists in passing the pulp as it leaves the plates into a *hydraulic separator*, a kind of crude spitzlutte. The pulp is here divided into two streams, one overflowing, carrying slimes with very fine sands; the other, consisting of coarse sands, some fine sands and slimes, which are conveyed by means of an india-rubber hose to the leaching tanks, in which one or more Kaffirs are employed to effect the even distribution of the pulp, by moving the hose about to different parts of the vat. The water passes off by adjustable gates fitted inside the vats, carrying with it fine sands, slimes, and some coarse sands. The advantages of the process are:—

1. This method treats pyritic tailings with the minimum of oxidation, as they are not exposed to the action of the air from the time they leave the battery.

2. A second handling of the tailings before treatment is avoided.

3. A preliminary rough concentration, or rather classification of the coarser particles of the tailings is effected.

There is at present a great controversy going on regarding the advantages of direct filling as against intermediate filling, and according to Mr. Bettel the disadvantages of the process are:—

- “1. The tailings pack tightly in the vat, and consequently do not drain completely, and a diffusion of the first cyanide

solution which is applied takes place at the commencement of leaching, causing loss of cyanide and gold. At the Crown Reef works I noticed that the distribution seemed to be pretty regular, and drainage can be assisted by means of exhaust pumps.

"2. The distribution of the sands and slimes is not so even, and some sands escape treatment, being protected by impervious layers of slime, the cyanide naturally escaping by the paths of least resistance. In leaching tanks where an uneven distribution of slimes and sands takes place, the slimy portion will not drain off; and on discharging such a tank, it is easily noticed that the streaks of slime are saturated with moisture and are still gold bearing, whereas the sandy portion has the solution drained off. The importance of an even distribution and mixture of the pulp can hardly be estimated.

"3. At most of the works where direct filling is introduced, square cement tanks are employed, and the discharging of these is not so practical as the wooden ones fitted with bottom discharges."

In Plate III. (Fig. 6), the tailing wheel, vanner room, and cyanide vats at Jumpers' mine are shown in section.

The Filter or Leaching Tanks.—These are, in most instances, made circular, that form being the strongest. They are from 20 to 42 ft. in diameter, and from 8 to 14 ft. in height, and should be constructed of well-seasoned lumber, with staves 3 to 4 in. thick, having their inner and outer faces cut to correspond to the arc of circle of the tank, and their edges radial to this circle (Fig. 7). The staves are not tongued or grooved, the pressure of the hoops being sufficient, if the tank is well made, to make them perfectly tight. The staves should be at least 1 ft. longer than the inside depth of the tank, and gained from $1\frac{1}{4}$ in. into the bottom timbers, with a chime of several inches.

The bottoms are made of 3 by 9 in. deals, tongued and grooved (Fig. 8), and put together with white lead, or litharge and glycerine. The hoops should be made by wrought iron



rods from $\frac{3}{4}$ to $1\frac{1}{2}$ in. in diameter, according to the size of the tank, with threaded ends passing through wrought iron lugs and tightened by hexagonal nuts. When the tanks are of large diameter these hoops are made in sections. The outside of the tanks can be painted in lead paint.

The bottoms of the vats rest on wooden beams 6 by 9 in., placed 18 in. apart. These beams are placed across the stone

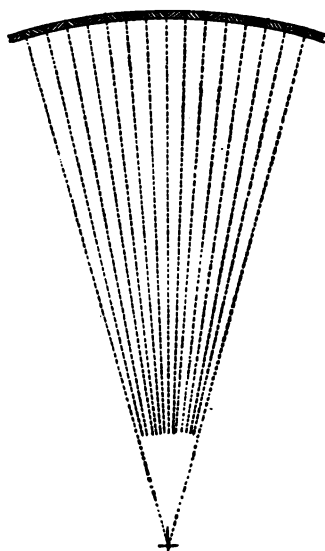


FIG. 7.—STAVES CUT TO CIRCLE.

foundation, and rest in their turn on planks $1\frac{1}{2}$ by 11 in. The planks are put between the stone foundation and the beams to merely ensure a perfectly level surface.

The construction of these vats should not be entrusted to the hands of any other workmen than experienced coopers.

It is obvious that tanks holding such enormous weights should rest on good foundations, and in every case where

wooden foundations have been used the result has been that the tanks settled, got out of plumb, and leakages occurred.

The filters are constructed of wooden slats, $1\frac{1}{2}$ by 4 in., set 12 in. apart, fastened to the bottom by wooden pins. Grooves $\frac{3}{4}$ in. deep and 3 in. wide are cut in a number of places in the bottom of these slats to allow a free passage of the solution along the bottom. On top of these slats are laid strips

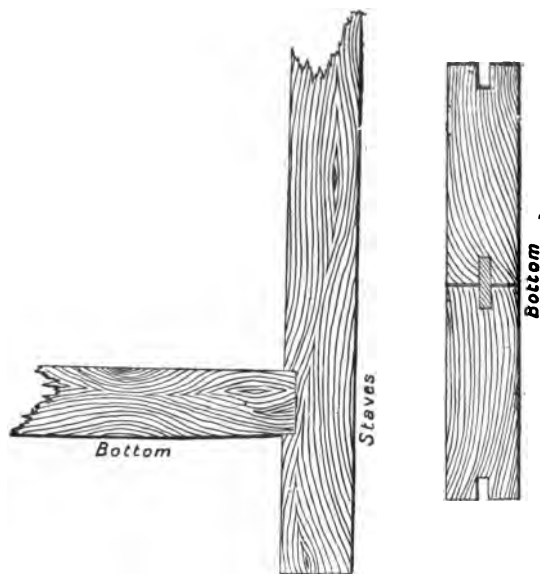
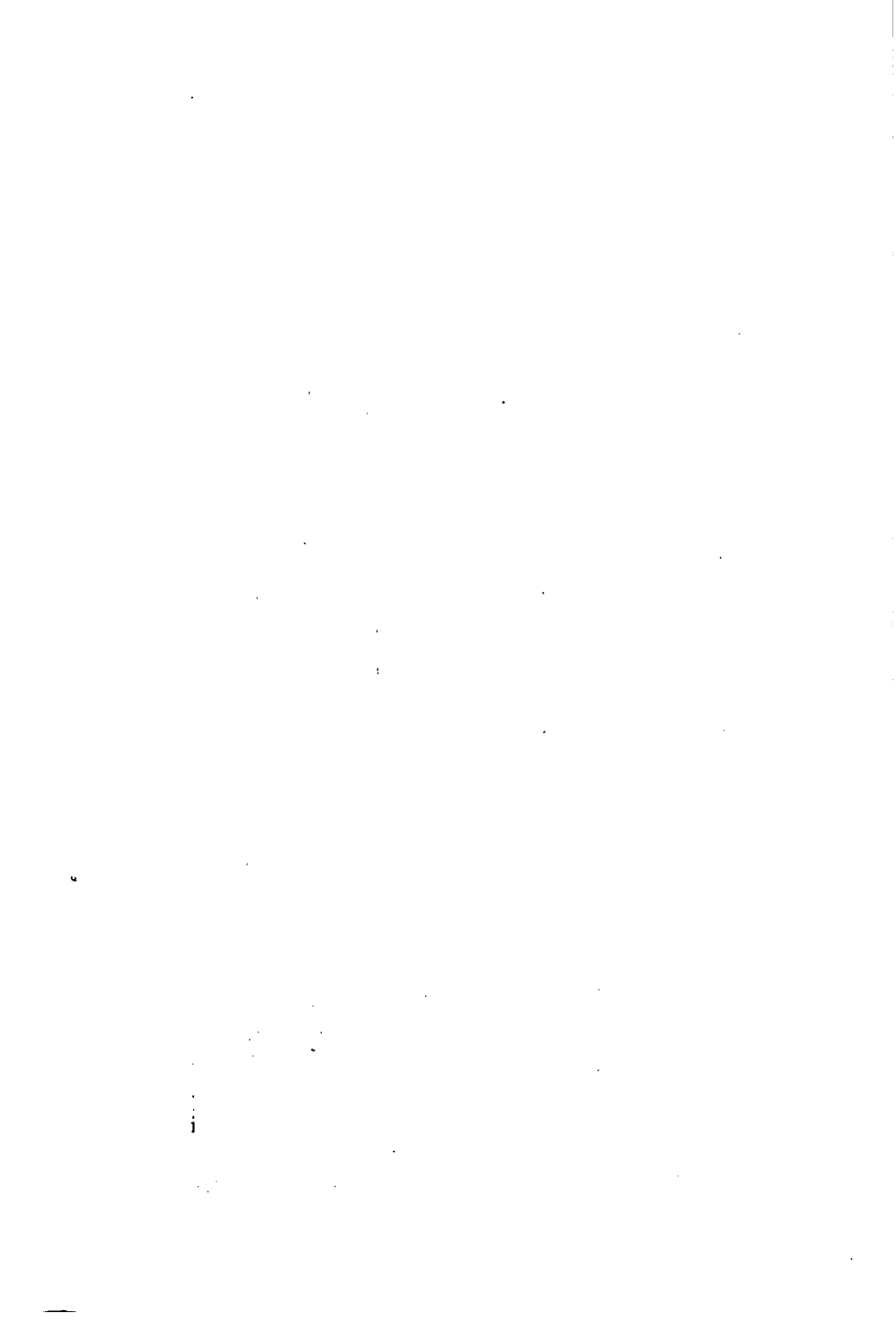


FIG. 8.—CONSTRUCTION OF FILTER VATS.

of wood 1 by 1 in., only 1 in. apart from each other, making openings 1 in. square. Between the ends of this wooden grating and the inside of the tank an annular space of about $1\frac{1}{2}$ in. wide is left, which is partly filled by a strip of wood 1 in. thick, bent to the circle of the tank. Over this and the slats is placed cocoa-nut matting and burlap, and held by a rope $\frac{1}{2}$ in. in diameter, which is driven into the space remaining between





the strips of wood and the staves of the tank. On top of the matting are laid again slats of wood 1 by 3 in., parallel one to the other, about 6 in. apart, their object being to protect the matting from being injured when shovelling the tailings through the man-holes into the trucks below.

The stone foundations are usually 6 ft. 6 in. high above the level of the rails, and are composed of a series of walls closed at their ends, leaving one or two passages underneath for the trucks (Fig. 9).

Each leaching vat has a separate drain pipe, 1 to 2 in. in diameter, and these pipes are so arranged in the extractor house, as to lead the strong solution to the strong extractor box

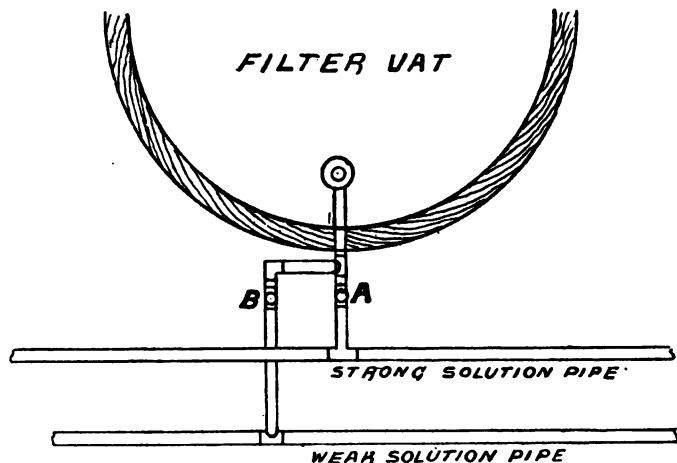


FIG. 10.—SOLUTION PIPES.

and the weak solution to the weak extractor box. In some works there is one main collecting drain pipe for strong solution and one for weak solution, and the connections are shown in Fig. 10. By shutting the valve, A, leading to strong collecting pipe, and opening valve, B, leading to weak collecting pipe,

the flow is regulated. Filtration is best assisted by causing a vacuum under the filter bed ; by connecting the drain pipe with a steam pipe and passing a jet of steam through the same, a vacuum is created under the filter bed.

I should also mention that the best and cheapest method of discharging the tailings from the leaching vats is to sluice them out from a side door, but for this purpose a stream of running water is required, which on these fields is not available.

Mr. Feldtmann * describes a system of discharging tailings from the leaching vats through a bottom discharge door into a launder, whence a copious stream of water carries the residues into the creek below,

The discharge doors can also be made on the side of the vat when the residues are to be sluiced out.

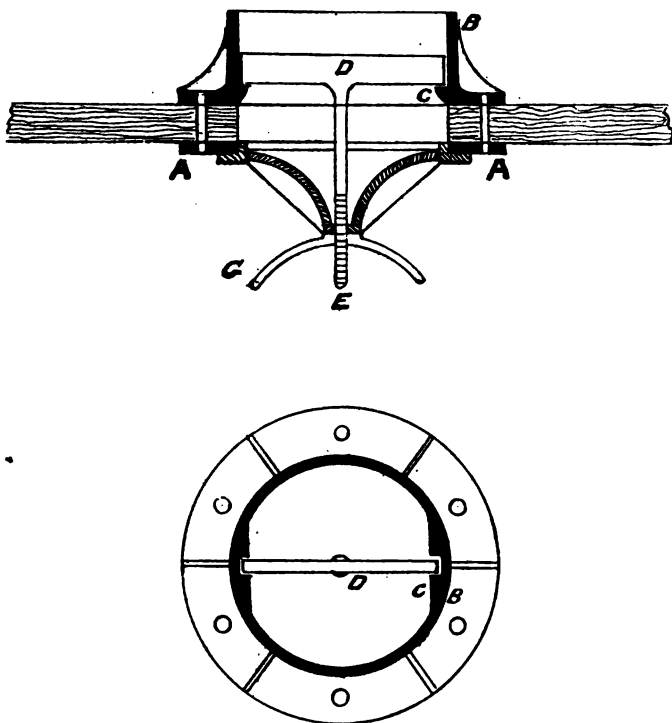
The round wooden filter vats on these fields are discharged by bottom discharge doors, which are closed by means of Butters' discharge lids. According to the size of the vats, there are two, four, six, or eight of these discharge openings to each vat.

Figs. 11, 12 show the arrangement. On the bottom side of the tank a cast-iron ring, A, is bolted to the cast-iron cylinder, B, inside the tank. Inside the cylinder is the projecting lug, C, upon which rests the hanger, D, which forms part of the screw, E ; the cast-iron cover, when placed in position, is simply fastened by the nut, G, and, screwing the same firmly, the whole arrangement becomes water-tight. The faces of the ring and the cover should be planed, so as to make a good joint. There are other methods of closing the discharge openings. When a tank is to be filled, a clay luting is given inside the iron cylinder, and then the same is rammed full with tailings. When filling the tank with tailings, especially into deep vats, a length of 3 to 4 ft. pipe is put over the discharge holes, and then the tailings are dumped in. It will be easily understood that in discharging a deep tank it facilitates the running of the tailings into an outlet if the same is within a few feet of the surface,

* "Notes on Gold Extraction." Argus Printing and Publishing Co., Johannesburg, 1894.

instead of having to push them down 13 or 14 ft. by means of long poles.

The cocks and valves should be of iron.



FIGS. 11, 12.—BUTTERS' DISCHARGE LID (SCALE 1 IN. = 1 FT.).

Pumps.—Several varieties of pumps are used to raise the solution from the sumps to the lixiviation tanks, and to provide circulation if needed. Centrifugal pumps are mostly used on these fields.

Stock Solution Tanks.—There are generally three solu-

tion tanks at each plant, built very much the same as the leaching tanks, with the exception that they have no filters, man-holes, &c. They are of different capacity, according to the size of the works, and are required to be of sufficient dimensions to store enough solution to keep the works going, without having to run any to waste.

Inside the tanks are gauges indicating the volume of solution. The stock solution tanks are usually 20 ft. in diameter, and from 7 to 14 ft. in height. One is for strong, one for weak solution, and one for alkaline wash. Every foot in height in a 20-ft. tank represents 10 tons of solution of 2,000 lbs. per ton.

To calculate the cubic contents of a circular tank, the following formula is employed. Multiply the square of the radius (10^2) with 3.14, and the product by the height of tank (6 ft.).

$$10^2 \times 3.14 \times 6 = 1884 \text{ cubic feet.}$$

1 cubic foot of water weighs 62.3 lbs. Therefore,

$$1884 \times 62.3 = 117573 : 2000 = 58.78 \text{ tons of water.}$$

If we desire to prepare a 0.3 per cent. stock solution,

$$\frac{117573.2 \times 0.3}{100} = 352.71 \text{ lbs. of cyanide will have to be}$$

dissolved in it, making allowance for any impurity in the cyanide. After treatment we find that the solution analyses only 0.16 per cent. Consequently, by multiplying

$$\frac{117573.2 \times 0.16}{100} = 188.11 \text{ lbs. is left in the solution ; and}$$

to make the same up to 0.3 per cent., another 164.61 lbs. of cyanide will have to be added.

Zinc Precipitation Boxes.—These are made of 1 to 2 in. boards, and are oblong boxes of various dimensions, which have to be in proportion to the quantity of solution which passes through them. In large works, the boxes are 20 ft. or more in length, 3 ft. high, and 3 to 4 ft. wide. There are separate boxes for the strong and for the weak solutions to pass through. At most works there are four of these boxes, placed in what

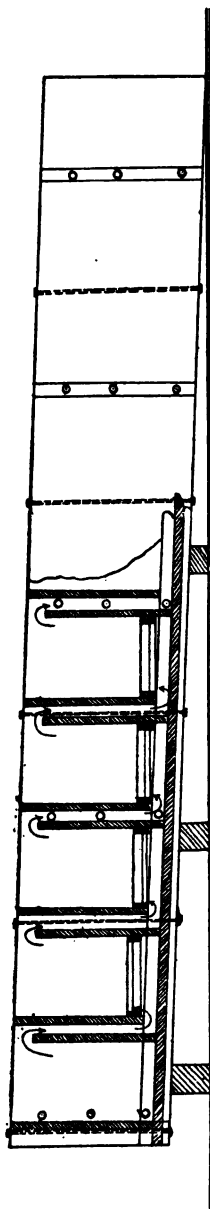


FIG. 13.—ZINC PRECIPITATION BOX.

is called the extractor-house, which also contains the machinery, pumps, furnaces, &c.

The precipitation-box is divided into several compartments by partitions and baffle boards, in such a way that the solution is forced to flow upward through the zinc shavings, which are held in trays several inches above the bottom of the troughs. Fig. 13 shows the construction of the troughs.

The first division has not got any zinc shavings in the same, as here the solution enters, and any sediment or fine slime which may have passed through the filter settles here. If any intermediary settling tanks are used, as at the Worcester works, this first compartment can be utilised also to hold zinc shavings. From the first compartment the solution flows over the partition, and then down the space, and upward through the tray holding the zinc shavings. The baffle-board is held in place in the position shown in the drawing by being nailed fast to the sides, and reaches a few inches above the level of the solution. From this explanation it becomes clear that the solution has to pass its downward and upward course till the last partition is reached, and from here passes through a pipe to the collecting sump or tank.

The zinc box compartments are fitted with removable trays, made of

wooden frames supporting wire screen of $\frac{1}{8}$ -in. mesh. The gold in the solution settles on the zinc as a brown coating, and which soon, as it accumulates in a finely powdered state, falls through the screens to the bottom of the trough. In the last partition of each box there is no zinc, but the tray here is utilised to hold cyanide of potassium in lumps to make up its standard strength before pumping the same into the storage tanks.

Over the zinc there is placed a light wooden grating, and the whole trough can be covered by a strong wire netting to secure against theft, as the same can be kept under lock and key.

At some works a wooden launder, covered with a lid and also under lock and key, is attached longitudinally to the box, and from each compartment in the trough when a clean up is made, a plug is withdrawn and the slimes which have accumulated in the bottom are washed through the launder on to a filter and collected. In most works, the clean-up is made differently, as described later on. The zinc trays rest on cleats, several inches above the bottom, and have handles on the sides so that they can be easily lifted out when cleaning up. After passing through the precipitation-boxes the solution is pumped back to the storage tanks, and is used continuously and not run to waste. The dissolved zinc does not accumulate in the stock solution to a great degree, and is probably precipitated in the lixiviation tanks with the charges of fresh ore.

CHAPTER II.

EXTRACTION BY CYANIDE.

Synopsis of the Process.—On the Witwatersrand gold fields, the cyanide process has been mainly adapted to the re-treatment of the tailings. As the largest proportion—and amongst it the coarser particles of gold—have been extracted by previous plate amalgamation, the precious metal in the tailings is in a very fine state of division, and therefore amenable to cyanide treatment. It must be here remarked that the coarser the gold, the longer it takes to dissolve it; and it is recommendable, therefore, that all ores should be first submitted to plate amalgamation before submitting them to the cyanide treatment.

When the first cyanide works were erected on these fields, the old accumulated stocks of tailings had to be dealt with. Owing to their long exposure to the atmosphere, changes had taken place in their chemical composition, which caused at the onset some difficulties, but these were soon overcome on the application of the proper remedies. The ores which came from the upper levels, or the oxidized zone, always carry a small proportion of iron pyrite, which, on exposure, becomes oxidized. It is only when free milling ore tailings are taken directly from the battery to the cyanide works that they do not

contain any decomposition products and are in a proper condition for cyanide treatment.

The course of the treatment in its successive stages may be thus summarised :—

First Stage.—Passing an Alkaline Solution or caustic wash through the ore to the point of saturation, as the tailings always contain a certain amount of organic matter, acid salts, &c. By running on this alkaline solution, a considerable saving is effected in the consumption of cyanide of potassium, and the tailings get the advantage afterwards of the full strength of the strong solution. Strength of this first alkaline solution may be 0·15 per cent. KCy., and may contain 4 ozs. of caustic soda per ton of solution. Caustic soda dissolves out organic matter. Excess of lime destroys cyanide.

Second Stage.—The Strong Cyanide Solution.—This solution varies in strength from 0·3 to 0·5 per cent. in KCy. to suit the richness and nature of the tailings under treatment, and the proportion of solution to be run on should not be less than one-third the weight of tailings in the vats. When this solution is run on, though the first solution has drained out, the tailings still contain a considerable quantity of the former solution. This should be displaced by allowing the second solution, or strong solution, to drain down immediately the vats are filled with the strong solution, for say about two hours (according to the capacity of vats and nature of tailings), and when this has been displaced, sufficient strong solution should be run on to make up the required proportional amount.

The vat is now full of strong solution, which, in some cases, may be leached out immediately, though generally it is advisable to leave it in contact with the mass for a short period—say, three hours—to give the solution time to penetrate any lumps.

When this solution is leached out, or only a very small stream is coming away, it should be allowed to continue draining about four hours longer. During these last four hours air is taking the place of the solution, and the gold is in con-

tact with a strong solution of KCy., in presence of oxygen, which produces a more rapid and effectual dissolving of the gold.

For proof: Take two watch glasses, fill both with cyanide solution of the same strength. In one, place a piece of gold leaf on the surface of the solution, while in the other immerse the gold under the solution. The gold leaf on the surface in presence with air disappears rapidly and is completely destroyed, whilst the other dissolves very slowly.

Third Stage.—The Weak Solution.—After the strong solution has been run on, we may safely assume that most of the gold is now in solution, and the object of the third operation is to wash out the dissolved gold. Therefore, after the strong solution has been drained out, sufficient weak solution containing 0.15 per cent. KCy. is run on till the total quantity of solution and washes represent 75 to 80 per cent. of the weight of the ore.

Fourth Stage.—The Water Wash.—After the weak solution, water wash is applied, and the quantity so applied is not to be less than 7 per cent. of the weight of the ore, and, indeed, more is necessary.

The Precipitation.—The cyanide solutions containing gold, as they flow from the leaching vats, are passed through one or more precipitation boxes. On the zinc shavings the gold is precipitated, and the quantity of solution flowing through each box must be properly regulated. The only satisfactory method of knowing if proper precipitation is taking place is by having the solution regularly assayed. This is an important point, as good results cannot be obtained if the solutions leaving the precipitation boxes are rich in gold.

It is essential for the man on the shift to know the strength of the solution at the different stages of leaching: first, that he may know into which one of the precipitation boxes the solution is to be passed; and then he must ascertain the strength of

the solution leaving the precipitation-boxes, in order to let them flow into their respective storage tanks.

The gold in solution increases and decreases in quantity much in the same way and same time as the cyanide in solution increases or decreases. In the precipitation of the gold in the boxes, it is important to keep a sufficient stock of zinc shavings in each compartment, and so to regulate the flow of solutions as not to incur danger of fine gold precipitate being carried away. The zinc shavings are prepared by turning down zinc discs on a lathe. The discs for this purpose may be cut out of No. 15 gauge metal, and may measure from 6 to 12 in. in diameter, a hole being punched in the centre for the mandril. It is usual to put bundles of twenty such discs on a mandril. The speed of the lathe may be anywhere from 150 to 350 revolutions per minute, and the shavings are turned off by hand with an ordinary carpenters' mortice chisel.

Precipitation of the gold varies somewhat with different classes of ore treated. The completeness of the precipitation appears to depend in a measure on a slight excess of cyanide of potassium being present in the solutions. Roughly speaking, it may be said that if solutions leaving the zinc boxes assay more than 2 dwts. per ton, the precipitation is not as it should be. This may be owing to the paucity of zinc in the boxes, which should be instantly rectified; or to too great a speed in the flow of the solution; or, in very exceptional cases, to insufficient cyanide in the solutions.

In the case of some Lydenburg cupriferous ores, it was found that, by making the solutions up to working strength before passing them through the zinc boxes, the result was that solutions which had before assayed several ounces were reduced to a few dwts. per ton.*

The zinc shavings in the boxes may require replenishing every day to replace the amount consumed, or they may run a week at a time without requiring replenishing.

Having, by passage of the solutions through the zinc shavings, reconverted the gold into the metallic form, the

* According to Mr. Feldtmann.

process of collecting the metal and putting it into ingots will be another stage of operations, and this will be described presently under the clean-up.

The exposure of the solution to the zinc after the gold is precipitated can only result in a loss of zinc, and—what is of much greater importance—unnecessary decomposition and loss of cyanide.

The precipitation boxes are set at a slight grade, as shown in the plan. Mr. Philip Argall, M.R.I.A., says that no iron or metal, other than zinc, should be exposed to the solutions in boxes; even the iron wire screens, used to support the filiform zinc, have been shown to cause an unnecessary consumption of zinc and cyanide, through the electro-chemical action induced between the metals.

Conditions which Influence Precipitation.—Mr. W. Bettel states that in the precipitation of various metals from cyanide solutions by zinc, the precipitation is influenced by the following conditions :—

- (a) Different strengths of solvents.
- (b) Impurities in solutions (which may be derived from ores) affecting precipitation.
- (c) Influence of rate of flow of solution through extractors, —past a given area of zinc—in gallons per minute.
- (d) Amount of gold in solution to be precipitated, and maximum precipitation from solutions of various richness.
- (e) Effect of alkalinity, acidity, or neutrality of liquors on rate and percentage of precipitation of metals from cyanide solutions.
- (f) Influence on the rate of precipitation of gold of such inert substances as carbonate of lime, clay, oxide of zinc, and coating of zinc, &c.
- (g) Other physical conditions of zinc, affecting precipitation of metals from cyanide solution.

Time taken by Treatment on Clean Tailings.—The method of treatment described below has been adopted at the Rand Central Ore Reduction Company's works, the figures

having been kindly supplied to me by the working chemist, Mr. Blomfield :—

1st. *Alkaline Wash.*

Filling with 0.16 per cent. KCy. + 4 oz.

Caustic soda per ton solution . . . time 2 hours.

Leaching " 3 "

2nd. *Strong Solution.*

Filling with 0.35 KCy. solution and contact . . . 5 "

Leaching " 8 "

Leaching dry " 4 "

3rd. *Weak Solution.*

4 washes at 1 hour each " 4 "

4 leachings at 4 hours each " 16 "

4th. *Water Wash.*

Filling " 1 "

Leaching " 7 "

Total time 50 hours.

This treatment was applied to $7\frac{1}{2}$ dwts. tailings, residues being from 15 grs. to 1 dwt. per ton; $\frac{3}{4}$ lb. of cyanide being the consumption per ton of ore.

On these fields it has been found that 12 to 24 hours' contact with the strong solution is sufficient to effect a solution of the gold in the tailings. The subsequent treatment with weak solutions has the object to displace the gold solution and to wash out the already dissolved gold. The displacing of the weak solution by a final water wash tends to reduce the loss of dissolved gold to a minimum, as it displaces the weak gold solution, and the gold which is left in the tailings is generally that still retained in the coarser quartz particles, from which it has not been liberated by stamping, and whatever gold has remained undissolved in the iron pyrites.

The time of treatment of each vat varies, and takes from 50 to 140 hours, according to circumstances, and the size of the tanks employed.

The Clean-up.—In making the clean-up, the tray holding

the zinc shavings is lifted out from the last compartment, and pulsated up and down in the solution, so that the fine particles of slime and zinc fall through the sieve and settle in the bottom of the box. Before starting this operation, it is advisable to run into the box a sufficient amount of clean water to remove the cyanide solution, as the latter is injurious to the workmen. The Kaffirs, however, put their arms and hands into it without being affected. The zinc shavings are taken out of the tray, which is placed on a rack above the box, so as to allow solution to drain back into the box. They are also rubbed in the water, to remove, as much as possible, all gold adhering to them.

The tray is turned over and brushed down so as to remove any gold adhering to it. The zinc shavings get very hot on account of oxidation, and it will be noticed that steam arises from them. They should be exposed, therefore, as little as possible to the air. The solution of water in the zinc boxes is pumped into settling tanks, where it is allowed to stand for two weeks, so as to give the extremely fine particles of gold which are held in suspension time to settle. In pumping out the precipitation boxes, great care should be taken not to disturb the gold zinc slimes in the bottom. With this aim, the water is pumped out to within 2 in. of the slimes, and the india-rubber suction hose moved into the second compartment, and so on.

The slimes are then pushed back with a scoop to one corner, and the supernated liquor allowed to stand for a while and pumped away again into the settling tanks. The slimes are now scooped into enamelled iron buckets and discharged on to a fine sieve—say 900 mesh—and washed and rubbed into the gold clean-up tank.

After the water is settled in the clean-up tank it is syphoned or pumped off, and the precipitate (called gold slimes) is drawn off through the plug holes on to a calico or linen filter, or into a filter press.

The zinc shavings, some of which will be found to have quite a brown coating of gold, which cannot be removed even

by rubbing, are again returned to the precipitation-boxes, and fresh zinc put on top. The gold which sticks to the zinc will be recovered in the next clean-up. After the gold slimes are sufficiently dry to be handled with a scoop, they are dried on an iron plate or on iron pots, and are then ready for roasting and smelting.

The object of the roasting is to oxidize the greater portion of the zinc which, in the form of small chips and shavings, has fallen through the zinc box trays, so as to cause it to combine in the subsequent smelting with the fluxes and leave the bullion fairly fine. Oxidation by the aid of atmospheric air is sufficient, but a certain amount of the zinc oxide subsequently becomes reduced by the carbon of the plumbago melting pots, and re-enters the bullion.

A good method of roasting has been found to be the addition of a little nitre, say about 3 to 10 per cent. to the precipitate. Mr. Feldtmann suggests that it is best applied as a strong solution before drying the precipitate, so that it gets equally mixed with the whole mass. In the subsequent roasting, the nitre not only assists by yielding up oxygen to the zinc, but to some extent also appears to flux the zinc oxide, forming zincate of potash, which is not so readily reduced as zinc oxide. Where the precipitate is very sandy—owing to tailings coming through the filters—nitre roasting is not so successful, as it tends to cake. By the addition of nitre the tendency of the precipitate to dust on stirring up in the roasting furnace is minimised, the amount of flux required in smelting is reduced, and the resulting bullion is better.

In roasting the precipitate care should be taken not to raise the temperature much above a dull red heat (to avoid partially fusing it to a pasty mass), and not to stir too violently, especially just at the commencement of the roast, or dusting and consequent loss is the result.

Mr. Butters, at the Rand Central works, has a muffle-roasting furnace in which to dry and roast the slimes. The bottom of the furnace consists of a cast-iron pan, and the wet slimes are charged on to this pan, and, when dry, a damper is closed,

which turns the flame through an opening in the fire-bridge, under the iron pan, and the slimes are carefully stirred to avoid dusting, and as much of the zinc as possible is driven off during the roasting.

The clean-up is generally made once a month.

Smelting of the Slimes.—The dried precipitate is now ready for the smelting process, and graphite crucibles are employed for the operation. The fluxes commonly used are bi-carbonate of soda, borax, and sand.

Examples of various fusing mixtures are given below, but it should be well understood that any one of the fluxes may have to be increased or decreased according to the amount of impurities present:—

	1. Clean Precipitate.	2. Very zincy Precipitate.	3. Very sandy * Precipitate.
Precipitate . . .	30 lbs.	30 lbs.	30 lbs.
Bi-carbonate soda . .	15 „	15 „	20 „
Borax . . .	8 „	12 „	10 „
Sand . . .	5 „	5 „	—
Fluor spar . . .	—	—	2 „

Precipitate and fluxes are well mixed and charged into the plumbago crucibles. The smelting furnaces, which may be constructed to take two or three pots at a time, should be good ones, as the heat required for this first fusion is rather in excess of the ordinary gold melting temperature. After the charges in the pots are run down, more of the mixture may be added from time to time—the whole of a charge, as given above, will go into two No. 35 crucibles—and everything being fused until perfectly liquid, the contents of the pots are poured into moulds. Conical-shaped moulds are the best suited for this work. The metal settles to the bottom, and, after cooling, may be turned out and freed from the slag by breaking off the latter with a hammer. The slags, which contain a large percentage of silicate of zinc and soda, corrode the pots, and during smelting there is a heavy evolution of fumes of zinc

* According to Mr. Feldtmann's formula.

oxide, causing, most likely, losses of gold. At the Robinson Mine condensing flues connect the furnaces with the chimney.

The several pieces of bullion thus obtained at one clean-up, are, consequently, remelted with borax and run together into one ingot. This remelting should be done at as low a temperature as possible, so that the metal may solidify almost as soon as it is in the mould, otherwise liquation results, and it becomes exceedingly difficult to obtain anything like a representative sample of the bullion for assay. The slags, which generally contain a considerable amount of gold in beads, are crushed up and panned, or cradled, to obtain the metal.

The slags from this operation are difficult to re-smelt, which may be owing to the presence of carbon contained in the zinc. At the Rand Central ore reduction works, Mr. Butters is erecting a small matting furnace, where he intends to smelt the slags with copper ore concentrates and collect the gold in a matte.

The fineness of the bullion resulting from the cyanide process ranges from 600 to 800.

Besides gold, silver, and zinc, there is some lead in the ingots, as the zinc employed contains a certain per cent. of this metal, and also carbon, which also is found in the ingots.

The zinc supplied by the Vieille Montagne Company is the best and purest for the purposes of the process.

The Treatment of Acid Ores or Tailings.—Under acid tailings are understood those tailings which contain the decomposition products of the iron pyrites. These products consist chiefly of free sulphuric acid and soluble metallic salts, such as proto-sulphate or per-sulphate of iron, or insoluble basic iron salts. All these substances are destructive to cyanide, forming with it compounds useless in the extraction of gold. The reactions which take place, when these salts are in the tailings, will be found explained in a subsequent chapter (Chapter IV.) on the chemistry of the process.

The ores on these fields at a comparatively shallow depth become very pyritic, but outside of iron pyrites the main reef

series carries no other sulphur combinations, or, at least, in such small proportions, as to have no practical importance.

The treatment of acid tailings on these fields offers more difficulty than in the case of the "free ore tailings." The oxidation products of the pyrites have to be neutralized by the addition of alkalies or alkaline earths—either caustic soda or lime—with or without a preliminary water washing, to remove such soluble salts or "cyanicides" as may be present.

Caustic lime, in a powdered form, is generally added now on these fields. With very acid tailings—namely, pyritic tailings—which have been exposed for some time to the oxidizing influence of the atmosphere, as much as $2\frac{1}{2}$ lbs. per ton is added. With fresh tailings $\frac{1}{2}$ lb. of lime per ton of tailings is sufficient. In some works the requisite quantity of lime is added to each car load of tailings as the same is hauled up to the leaching tanks. In other works 6 or 10 tons of tailings are dumped into the leaching tank, and the same levelled off and the lime sprinkled over it. The practice of putting all the lime on top of the tailings after the vat is filled, cannot be recommended: the lime forms a pasty mass, and the alkalinity does not penetrate through the total height of the ore, so that in deep tanks it will be found that the top layer, say for one-third of the height of the ore, will be neutralized, whereas two-thirds nearer the bottom will remain acid. The length of treatment varies, and later on in this volume (Chapter III.) I am giving the *modus operandi* of the process at some of the principal works on the Witwatersrand.

Concentration and Treatment of Concentrates.—The question whether it pays to concentrate the tailings before sending them to the cyanide works has not yet been definitely settled on the Rand gold fields. Considering that during the short period of treatment which the tailings undergo, the gold cannot all be extracted from the pyritic particles, it seems rational that a separation of the pyritic matter should be effected, and the concentrates treated separately.

The only mines where concentration previous to cyaniding

has been carried out for any length of time are the Crown Reef and the Langlaagte Estate and Langlaagte Block B. Mines, where the concentrates are treated separately with cyanide. At these mines I am informed that it pays to follow this method.

Mr. Williams, of the Crown Reef, collects his concentrates by a crude system of classification, which costs him 10d. per ton of concentrates, whereas at the Langlaagte Estate Frue vanners are employed. The manager there informs me that the cost of cyaniding the concentrates amounts to only 17s. per ton.

I believe that when the question has been thoroughly studied it will be found that a system of proper concentration before cyaniding will pay. Up to the present there is not a single mine on the Rand equipped with a proper concentrating plant, as such ores as exist there have to be classified before an attempt can be made to concentrate them. At the Langlaagte Estate, where 22,000 tons of ore are crushed monthly, they get on an average 350 tons of concentrates, or about $1\frac{1}{2}$ per cent. ; this quantity could be easily doubled by the application of a proper plant. Most mills have Frue vanners, but this excellent machine cannot do the work alone on these ores. I may mention that Mr. Rademacher, engineer of the Humboldt works at Cologne, is now engaged at the Langlaagte Block B upon experiments with the view of concentrating the pyrites out of the slimy particles of ore. The results there will throw considerable light on the subject, and prove if I am right.

High extraction by cyanide can be obtained from concentrates, only the process does not seem to act alike everywhere on the concentrates, and possibly the physical nature of the pyrites is not alike in every mine. In some cases it may become necessary to grind the pyrites, so as to liberate the gold, and make it more amenable to cyanide. It is stated that gold contained in pyrites is extracted more easily when the concentrates are mixed with sands. Clean concentrates, therefore, are more difficult to treat, as owing to their high specific gravity they "pack" and resist percolation.

At the Crown Reef mine they collect by means of 3 spitzluten, about 600 tons of concentrates a month, out of 17,000

tons of ore. A $1\frac{1}{2}$ -in. pipe leads the heavy sands and pyrites to settling tanks 30 ft. in diameter and 6 ft. high, which assay 23 dwts. per ton. The main object of this rough concentration is to eliminate the coarse sands so as to submit them to a prolonged treatment with cyanide. The cost of this system of concentration is only £25 per month—namely, the pumping of the water which is needed for the hydraulic classifier—as they are worked by an ascending stream of water. The concentrates, or rather the classified material, by being collected in wooden vats, is constantly under water and does not get oxidized. The material collected is not very coarse, as in the battery they use 900-mesh screens.

From the storage tanks the material is taken to the leaching tanks, and submitted to the action of the solutions for 16 to 18 days. The strength of solutions employed is 0.25, 0.1, and 0.05 per cent. respectively; about 1 lb. of lime is added to each ton of concentrates. Strong solution is run on for 4 days or more, till its strength remains constant.

The residues from these concentrates assay $1\frac{1}{2}$ dwts., giving an extraction of 94 per cent. The consumption of cyanide with these concentrates is about $1\frac{1}{2}$ lbs. per ton. The weaker solutions are constantly circulated through the tanks till a high point of extraction is reached. The Witwatersrand ores carry from 3 to 4 per cent. of pyrites; and I believe the time of treatment could be lessened by employing a somewhat stronger solution.

At the Robinson mine 3 per cent. of the total weight of the ore is caught on Frue vanners, as concentrates assaying 4 to 5 oz. Extensive experiments have been made with cyanide, but the results were not satisfactory, and consequently the concentrates are treated at this mine by chlorination, which costs £3 per ton.

The tailings at the Robinson are elevated by means of a bucket-wheel, and passed through intermediate tanks, fitted with Butters and Mein's distributor; there are six intermediate tanks, and 30 per cent. of the ore goes into the slime pits.

The tailings, which go to the cyanide works, assay $6\frac{1}{2}$ dwts.

The slimes assay $5\frac{1}{2}$ dwts. ; and Captain Mein tells me that the residues, after cyanide treatment, assay only 1 dwt. This would mean a higher extraction than on any mine on the Rand. He finds that there is a discrepancy of 1 to 2 per cent. between the actual gold produced and that determined by assays.

Adverse Conditions which affect the Cyanide Treatment.*—1. The action of impurities and base metals in ores prevents solution of the gold and effects the decomposition of cyanide. This will require a complete study by analysis of the component parts of the ore.

It is necessary to examine the condition of gold in residual tailings or concentrates from the cyanide treatment.

(a) In this connection it has to be ascertained if a certain percentage of dissolved gold (the auro-potassic cyanide) has or has not been completely washed out.

(b) Also if a certain per cent. of gold is still present in coarse particles capable of being amalgamated.

(c) Also the percentage of gold encased in quartz, or pyrites, to which the solution has not had access.

(d) Also the occurrence of gold in lumps of slime after treatment by cyanide ; the gold supposed to be precipitated by the action of iron salts producing a ferrous ferricyanide from auro-potassic cyanide and free cyanide, thus explaining some low extractions from weathered ore and concentrates.

The presence of copper combinations is very detrimental to the success of the MacArthur-Forrest process. The ores of the Black Reef series, near Johannesburg, carry a small quantity of copper pyrites, and consequently the extraction of gold by cyanide does not give as good results as on the Main Reef series.

In this connection it is important to mention here a point which the inventors of the cyanide process have strongly emphasised—namely, the selective action of weak solutions of cyanide for gold in preference to other metals. It is a strange

* According to Mr. Bettel.

fact that, while gold is one of the most difficult of metals to dissolve in acids, it is extremely susceptible to the weakest solution of cyanide, when copper and other metals might remain unaffected in it. The successful use of very weak solutions may have much wider and more important consequences.

It is well known that the MacArthur-Forrest process has failed in some mining districts in the treatment of complex ores; and it has seemed to me not unlikely that when experimenters with the cyanide process have met with difficulties such as this, they have increased the strength of their solutions, using more cyanide in the hope of overcoming the disturbing presence of the baser metals.

I shall presently give an account of the process introduced by Messrs. Siemens and Halske, who have adopted the diametrically opposite course; they have taken weaker solutions. If they had confined themselves to the chemical precipitation of the gold upon zinc or some other metal, as in the MacArthur-Forrest patent, they would have failed, because a point arrives at which chemical precipitation, in exceedingly dilute solutions, becomes imperfect. But the introduction by Messrs. Siemens and Halske of the agency of electricity, solved the problem at once. Now it is quite possible that, when the complex ores of other countries are treated with very weak solutions and by the electrolytical method, the weak solution will attack the gold in the ore, but may leave the other metals unattacked. There is a wide field open here for investigation and research.

The Practical Results.—Before we begin the treatment of the tailings, we meet with an acknowledged loss of 25 to 30 per cent. of the gold which goes into the slimes. It is true this gold is not lost, for it is still there. It is still an asset which accumulates monthly by the thousands of ounces in the slime-pits; but in the present state of our science and knowledge it is unavailable, and, therefore, for present practical purposes, represents a loss which has to be reckoned with. It may be possible, and quite probable, that in other mining regions this

loss may not occur, but I put some emphasis on the point, as investigators in other countries will do well to closely study the nature of the ore they are dealing with before erecting their plant, and thereby probably save unnecessary expense on that head, to say nothing of costly experiments.

To illustrate the question of extraction by an example, I will suppose that we are dealing with a Rand mine whose ores contain an average assay value of 16 dwts. per ton.

I am safe in saying that the average extraction in the battery by plate amalgamation ranges from 60 to 70 per cent., especially from the pyritic ores; and, assuming that the battery recovers 10 dwts. per ton, or about 63 per cent., this would leave 6 dwts. in the tailings. Assuming now that 1,000 tons tailings at 6 dwts. go to the cyanide works, containing 6,000 dwts., 30 per cent. of these, or 300 tons at 6 dwts., containing 1,800 dwts., go to the slime-pit, leaving 700 tons of tailings at 6 dwts., containing 4,200 dwts., which go to the leaching-vats. Of these 4,200 dwts., 70 per cent. is recovered by cyanide, equal to 2,940 dwts., so that the amount recovered from the original 1,000 tons of tailings represents 50 per cent. in round figures, or 3 dwts. out of the 6 dwts. Add to this the 10 dwts. won on the plates, and we have 13 dwts., or a total recovery of 82 per cent. of the gold contained in the ore, which, when the slime treatment shall have been solved will be raised to about 90 per cent., which percentage can be considered highly satisfactory.

Exact figures as to the actual extraction of the gold from the various establishments are not easily obtainable, but from the information I have gathered, I should consider that 85 per cent. would be the average.

Cost of Treatment.—This necessarily varies at every plant, and mainly depends (1) on the size of the plant; (2) on the facilities for handling the tailings in charging and discharging; while (3) the principal item is the consumption of cyanide.

The consumption of cyanide, I should judge, varies from

$\frac{3}{4}$ to $1\frac{1}{2}$ lbs. per ton of tailings treated. The commercial article, as sold in Johannesburg, costs 2s. per lb.

The consumption of zinc is about 0·4 to $\frac{1}{2}$ lb. per ton of ore, and costs 4½d. per lb. in Johannesburg. At the Kleinfon-tein works the consumption of cyanide is only $\frac{1}{2}$ lb. per ton. The consumption depends greatly on the washing, and the alkaline wash destroying organic matter. The cost, in large works treating above 10,000 tons and over, would be 4s. per ton; in works treating 5 to 7,000 tons, 5s. to 6s.; in works treating 3 to 4,000 tons, 6s. to 7s.; while in smaller establishments the cost may even be higher.

The cost of zinc precipitation can be estimated at from 1½d. to 3d. per ton.

The Robinson Cyanide works treated, in 1893, 55,200 tons of tailings; in which was contained fine gold, 20180·06 oz., and from which was extracted fine gold, 13872·66 oz.; extraction, 68·7 per cent.; bullion returned, 17921·20 oz.

The cost of cyaniding was as follows:—

	Total.			Cost per ton.		
	£	s.	d.	£	s.	d.
Wages (whites and natives, including food)	3,406	11	8	0	1	2·81
General stores, assay material, &c.	1,408	9	1	0	0	6·12
Fuel	1,204	19	9	0	0	5·24
Cyanide—64,411 lbs. equal to 1·16 lb. per ton	5,563	0	2	0	2	0·19
Zinc—12,521 lbs. equal to 0·23 lb. per ton .	260	4	3	0	0	1·13
Contractor (filling and discharging vats)	4,325	12	2	0	1	6·81
Royalty	3,768	1	1	0	1	4·38
Total	£19,936	18	2	0	7	2·68

Cost of Plant.—A plant to treat 3,000 tons monthly would cost £5,000; a plant to treat 5,000 tons monthly, £7,500; a plant to treat 7,000 tons monthly, £10,000; and a plant to treat 16,000 tons monthly, £18,000. The figures being, of course, in each case approximate only.

CHAPTER III.

THE SIEMENS-HALSKE PROCESS.

The Electric Precipitation of Gold from Cyanide Solutions.—This process has been in practical operation at the Worcester mine for several months, where I have had the opportunity of observing and testing the operations. At the Meyer and Charlton mine, May Con, and at the Metropolitan, it will very shortly supersede the zinc precipitation method.

Upon reference to the plans (Plates V. and VI.—see pages 42 and 44) it will be noticed that the works are similar to those in use for the MacArthur-Forrest process, the only alteration being in the extractor-house.

For much of the information contained in this Chapter, I am indebted to a lecture by Mr. A. Von Gernet, delivered a few months ago before the Chemical and Metallurgical Society of South Africa. Great credit is to be given to Mr. Von Gernet for the ability which he has displayed in developing this new process on the gold fields.

How the Process was Discovered.—In 1887 Dr. Siemens, the eminent electrician of Berlin, found that the gold anodes, used in electro-plating at his works, lost weight when standing in the cyanide liquor without any electric current passing through the bath. This fact of course corroborated the statements made by chemical authorities that gold is soluble in cyanides, and induced him to try the use of cyanide solutions for the extraction of gold from ores.

He found that the zinc method, as introduced by MacArthur-Forrest, only gave good results with strong solutions, while the

electric precipitation was equally effective with either strong or weak solutions, and its efficiency was not lessened by the presence of caustic soda.

He subsequently introduced the process in Europe, Asia, and America, and during the year 1894 erected a plant capable of dealing with 3,000 tons of tailings per month at the Worcester mine, near Johannesburg, Transvaal.

The Action of the Electric Current on the Gold Solution.—The electric current decomposes a solution of a metallic salt, the metal being deposited on the negative pole, while the metalloid is liberated at the positive pole of the electrolytic cell. In a fixed time, a given electric current will deposit a certain quantity of metal, which quantity varies for different metals in direct proportion to their electro-chemical equivalents. This law holds good only for solutions strong in metal, but with very dilute solutions, as in use in the cyanide process, the current does not find sufficient of the metallic compound present at the electrodes, and consequently decomposition of water also takes place. For this reason, to make the efficiency of the precipitation as great as possible, constant diffusion of the solution is requisite.

In order, therefore, to create an artificial diffusion, a mechanical movement of the solution is important, and the most economical and convenient way of effecting this is to allow a slow but steady flow through the precipitation-boxes. But it is still more important to give a very large surface to the electrodes. In fact, a better effect is obtained by doubling the number of plates than by increasing the current tenfold.

Why Mercury cannot be used as a Cathode.—Mercury cathodes are not practical, for the reason that such an enormous quantity of this costly metal would have to be employed that the recovery of the gold would become difficult.

To precipitate 100 tons of cyanide solution containing 5 dwts. of gold per ton of solution in 24 hours, about 24,000 square feet of mercury surface is required. If the bottoms of

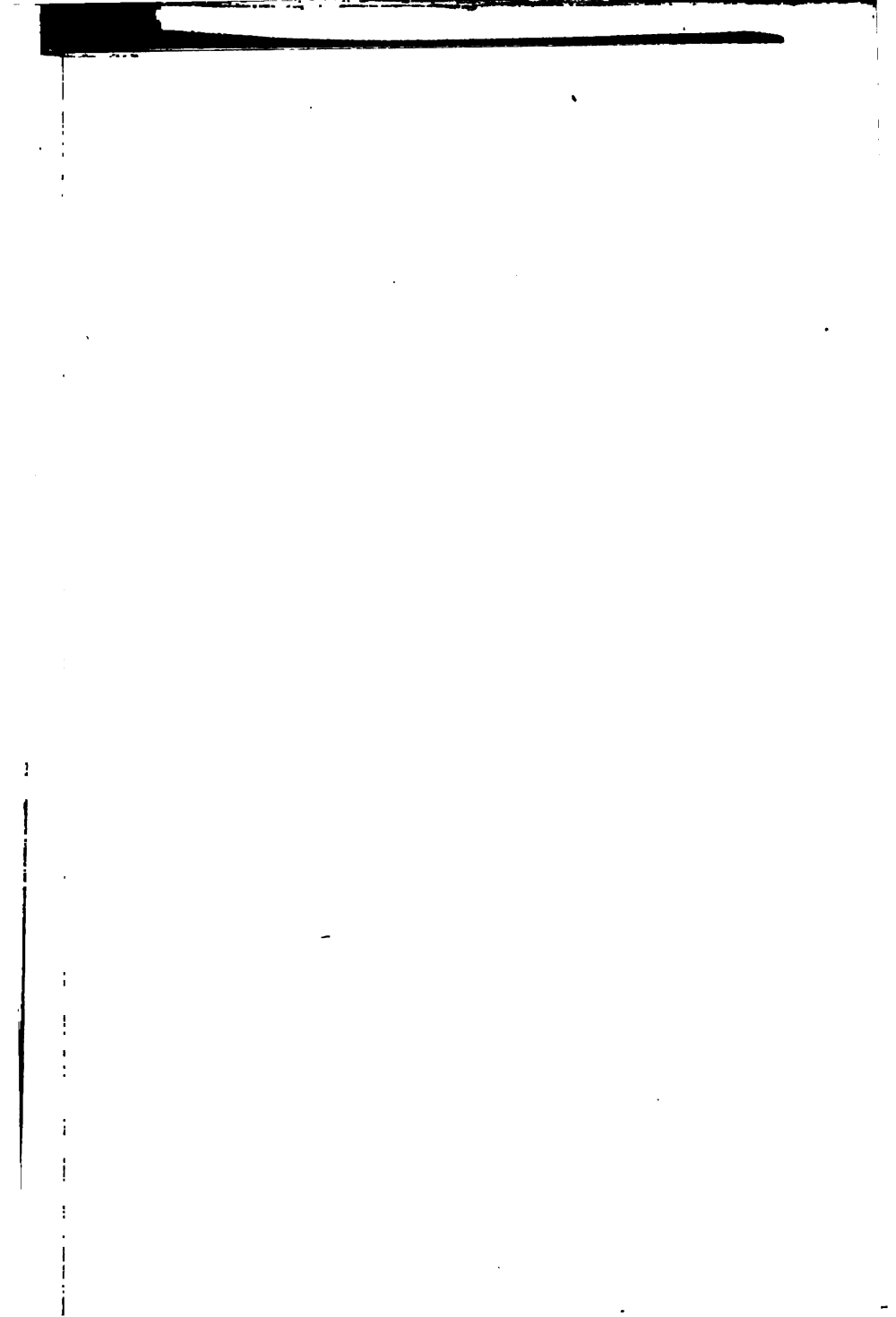
the precipitating-boxes were covered with mercury, it would be necessary to have it at least a quarter of an inch deep, to make up for differences of level, and thus ensure that the whole surface should be covered. This requires over 200 cubic feet of mercury, weighing 80 tons. At the end of a month there would be 750 oz. of gold in this enormous quantity of mercury; and even straining it most carefully, the gold would be so finely diffused that I doubt whether much of the gold would remain in the straining filter; besides, the practicability of such an operation is questionable. I do not consider the initial outlay of the mercury, and the large loss sure to result when handling such large masses of this metal.

The vertical position in which metallic plates can be placed has the great advantage of keeping the surface of the cathodes clean, as any solid matter entering the boxes in suspension sinks to the bottom of the latter, no obstruction being offered to its downward course. Sheets of solid metal (as copper), coated with mercury, have also been tried, but have been unsuccessful because the mercury, owing to the action of the current, will penetrate the copper and form a dry amalgam which does not adhere to the plates.

Conditions which the Metal Cathode must Fulfil.—

1. The precipitated gold must adhere to it.
2. It must be capable of being rolled out into very thin sheets to avoid unnecessary expense.
3. It must be easy to recover the gold from it.
4. It must not be more electro-positive than the anode, in order to prevent return currents being generated when the depositing current is stopped.

The most suitable metal for the purpose is lead, rolled out in very thin sheets, and this is accordingly used in the Siemens-Halske process, meeting all the requirements of the case. The lead sheets are fastened in light wooden frames. There are three sheets of lead, 2 by 3 ft. in each frame, giving each frame a surface of 18 ft., and 87 frames, which are in each precipitating-box, will expose a surface of 1,566 square feet.





Each frame holding three lead sheets at 1 lb. weight each, makes 261 lbs. of lead in each box. See Plate VII. (p. 46).

The Anode.—Not less important is the question of anodes. By the action of the current, a metalloid is liberated at the positive electrode, and the latter, when a metal, begins to oxidize. Carbon could be used as an anode, but it will not withstand the action of the current, and soon crumbles into a fine powder, which decomposes cyanide. This finely-divided carbon is in suspension, and cannot be removed from the solution by filtration. Zinc used as an anode forms a white precipitate of ferro-cyanide of zinc by the reaction of zinc oxide upon ferro-cyanide, formed during the leaching. Similarly, iron anodes form Prussian blue by the reaction of oxide of iron and ferro-cyanide. In consequence of this reaction the amount of ferro-cyanide in the cyanide solution does not increase.

From the Prussian blue the cyanide can be recovered by dissolving it in caustic soda, then evaporating the solution, and finally smelting with potassium carbonate.

This last process has been carried out only on a small scale, about 50 lbs. at a time, but a nice clean cyanide of potassium is obtained. In the treatment of tailings this regeneration of cyanide is not of great importance; but with concentrates, which decompose the solution with formation of ferro-cyanide, it will effect a considerable economy.

Electric Current required for Precipitation.—In order to precipitate the gold from cyanide solutions only, a very weak current is required, that is to say, a density of about 0.06 ampère per square foot. With cathodes about $1\frac{1}{2}$ in. apart, 7 volt is sufficient to produce this current strength.

The advantages gained by using such a weak current are :—

1. The gold is deposited hard on the plates.
2. The iron anodes are preserved for a long time, as their waste is in proportion to the current strength. In a plant

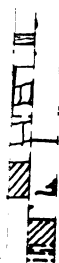
treating 3,000 tons per month, 1,080 lbs. of iron are destroyed in that period.

3. Little power is required. 746 Watts equal 1 horse-power. A 3,000-ton plant requires 2,400 Watts, equal, theoretically, to $3\frac{1}{2}$ horse-power, and actually requiring about 5 indicated horse-power.

Advantages of Electrical Precipitation. — The most important feature of electrical precipitation is, that it operates on the solution quite independently of the amount of cyanide or caustic soda it contains. Precipitation by means of a chemical reaction is invariably more complete with a solution strong in cyanide than with a weak one, but with electricity is absolutely of no importance whatever. Therefore, in the treatment of tailings, very dilute solutions can be used, the only limit being a sufficient amount of cyanide to dissolve the gold satisfactorily. Moreover, however acid the solution may be when entering the boxes, the precipitation takes place equally as well, the same amount of gold being recovered as from a neutral or alkaline solution. There are none of the complications arising from the formation of lime and alumina and hydrate of iron, which, under similar circumstances, sometimes occasion so much trouble in the zinc process.

A solution, containing 0.03 per cent. of cyanide, will dissolve gold just as effectively as a solution containing 3 per cent., provided a longer time is allowed for treatment. In the first case, the decomposition of cyanide in the tailings is much less than in the second, and a corresponding economy is effected. The moisture in the original tailings being usually about the same as that contained in the residues, there is, as a rule, no chance to give a large water wash after the cyanide treatment is finished. The residues discharged contain 10 to 15 per cent. moisture, carrying about 1 to 0.05 per cent. cyanide solution when the zinc process is employed. This is equivalent to $\frac{1}{4}$ lb. of cyanide per ton of tailings. This last may be reduced to $\frac{1}{8}$ lb. by using as weak wash a solution containing only 0.01 per cent. of cyanide, which strength will be perfectly

11



suitable for electrical precipitation, though difficult to deal with by the chemical method.

Practical experience has taught us that, if we treat an ore containing copper with a strong, say, 2 to 3 per cent. solution of cyanide, the potassic cyanide may be all decomposed, but if we apply a much weaker solution, say $\frac{1}{2}$ per cent., although the cyanide will be also decomposed, the same extraction of gold will be effected. So that, though in the former case the treatment may appear commercially impracticable, the proper carrying out of the process, by leaching with weak solutions, will prove to be both effectual and economical.

The presence of copper in the ores also may affect, to some extent, the second operation in the process, *i.e.*, the precipitation of the gold.

Mr. Feldtmann mentions in this connection the result of some experiments made by him on some cupriferous ores at the Transvaal Company's plant near Lydenburg, as illustrating the selective affinity which weak cyanogen compounds possess for gold, that although there was sufficient copper mineral present to decompose a solution of potassic cyanide of over 1 per cent. strength, still good results—*i.e.*, 70 per cent. extraction on 18 dwts. ore—were obtained with $\frac{1}{2}$ per cent. solutions. In this instance there was reason to believe that the gold was dissolved as auric cyanide instead of as auro potassic cyanide, as usually formed.

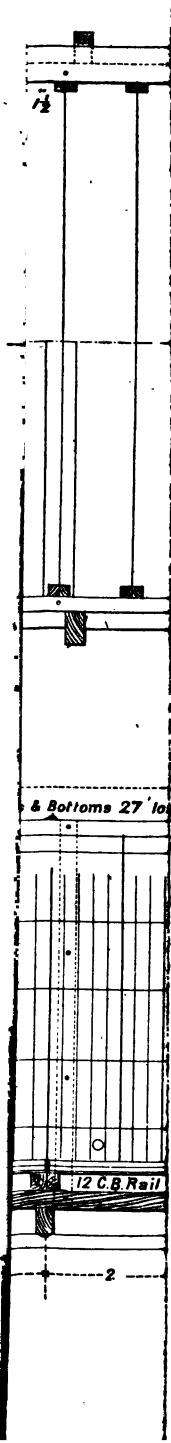
As I have already intimated, it is my belief that the application of the extremely weak solutions, such as are utilised in this process, will lead to important results in the treatment of the so-called rebellious ores. But further investigation of the subject is required.

The vats hold 135 tons, and it takes 5 hours to fill them. The tailings first get an alkaline wash of 10 tons, after which wash 70 tons of strong solution of 0.05 to 0.08 per cent. is pumped on; and afterward 20 tons of weak solution, of 0.01 per cent. strength, is pumped on. The total quantity of solution used is 100 tons, and it takes $5\frac{1}{2}$ days to leach, filter, and discharge each vat.

Practical Working Results.—At the Worcester works, which are in charge of Mr. Oswell, there are in use 5 leaching-vats of 20 ft. diameter with 10 ft. staves, each holding 3,100 cubic ft., 135 tons. One tank is discharged and filled every day. The strong solution used contains from 0.05 to 0.08 per cent. cyanide, and the weak washes 0.01 per cent. The actual extraction of fine gold has averaged 70 per cent., while the consumption of cyanide has been $\frac{1}{2}$ lb. per ton of tailings treated.

The precipitation plant consists of four boxes, 20 × 8 ft. wide and 4 ft. deep. Copper wires are fixed along the top of the sides of the boxes, and convey the current from the dynamo to the electrodes. The anodes are iron plates, 7 ft. long, 3 ft. wide, $\frac{1}{8}$ in. thick. They stand on wooden strips, placed on the bottom of the box, and are kept in vertical position by wooden strips fixed to its sides. In order to effect the circulation of the solution in passing through the box, some of the iron sheets rest right down on the bottom, while others are raised about 1 in. above the level of the solution, thus forming a series of compartments similar to those of a zinc precipitating-box, the difference being that the solution passes alternately up and down through successive compartments.

The iron sheets are covered with canvas to prevent short circuit. The lead sheets are stretched between two iron wires, fixed in a light wooden frame, which is then suspended between the iron plates. The boxes are kept locked, being opened once a month for the purpose of a "clean-up," which is carried out in the following manner:—The frames carrying lead cathodes are taken out one at a time. The lead is removed and replaced by a fresh sheet and the frame returned to the box, the whole operation taking but a few minutes for each frame. By this means the ordinary working is not interrupted at all, and the cleaning out of the boxes, which is necessary in the zinc boxes, is only required at long intervals. The lead, which contains from 2 to 12 per cent. of gold, is then smelted into bars and cupelled. The gold is deposited on the lead sheets as a thin, bright yellow film, which adheres firmly to the lead. The consumption of lead at these works is 750 lbs. per month,



equal to 1½d. per ton of tailings, and the working expenses for treating 3,000 tons per month are as follows :—

	£	d.
Filling and discharging leaching-vats 125 monthly	125	0·10 per ton.
Cyanide	75	0·6 "
Lime	15	1·2 "
Caustic soda	6	0·5 "
Lead	14	1·1 "
Iron	28	2·2 "
White labour	65	5·2 "
Native wages and food	20	1·9 "
Coal	57	4·6 "
Stores and general charges	41	3·2 "
	<u>£450</u>	or 3 shillings per ton.

At a great many works, where correct sampling and assaying is carried out, the results—that is, the gold won—agree pretty closely with the assay results. At the Worcester the following were the results for the month of August, 1894 :—

	Ozs.	Dwts.	Grs.
1,350 tons tailings taken from settling vats containing	443	1	0 gold
1·750 " " " upper tailing dam containing	498	15	12 "
3,100 tons tailings which according to assay contain	941	16	12 "
3,100 " residues " " " "	239	7	12 "
Balance, showing the theoretical output or 74·6 per cent.	702	9	0 "
Actual gold won, or 74·1 per cent.	697	15	15 "

The tailings which were treated assayed from 6 to 8 dwts. The tailings, or residues, after treatment, assayed from 1 to 2 dwts. The solutions which leave the precipitation-boxes still contain some gold, and the analysis in this case showed that the strong solution contained 4 dwts. 8 grs. per ton of solution. The weak solution contained only 10 grs.

On an average, in these works, strong solutions carry from 4 to 5 dwts., and the weak from 0 to 1 dwt.

In taking samples of the residue, it should be borne in mind that the portion of the residues in which the largest proportion of unextracted gold is contained is near the bottom of the filter-vat, say the last 12 to 15 inches.

The best way to sample is to take a sampling-iron and probe every carload as it goes to the works, and to do the like with every car as it leaves the works with the worked residues.

In the subjoined pages (50 to 56) will be found the details of a working scheme for one week, as carried out at the Worcester works; and to follow the method of treatment, I have chosen vat No. 4, as an example.

On the 20th August, 1894, this vat, which holds 135 tons has been filled with tailings. It takes about five hours to fill such a tank. One ton of tailings is equal to 27 cubic feet.

From 3.15 p.m. till 6.20 p.m. 10 tons of the alkaline wash are pumped into the vat . . . 10 tons

At 8.10 p.m.	strong solution is pumped on .	5 tons
" 10.45 "	" " " " " "	5 "
" 3.30 a.m.	" " " " " "	5 "

21ST AUGUST, 1894.

At 9 a.m.	strong solution is pumped on .	5 tons
" 1 p.m.	" " " " " "	5 "
" 5.20 "	" " " " " "	5 "
" 10.15 "	" " " " " "	5 "
" 3.40 a.m.	" " " " " "	5 "

22ND AUGUST, 1894.

At 9.15 a.m.	strong solution is pumped on .	5 tons
" 1.30 p.m.	" " " " " "	5 "
" 6.30 "	" " " " " "	5 "
" 9.35 "	" " " " " "	5 "
" 4 a.m.	" " " " " "	5 "

23RD AUGUST, 1894.

At 7.30 a.m. strong solution is pumped on . . .	5 tons
Total strong solution . . .	70 tons
At 1.50 p.m. weak solution is pumped on . . .	7 tons
„ 7.15 „ „ „ „ . . .	7 „
„ 1.25 a.m. „ „ „ „ . . .	7 „
Total weak solution . . .	21 tons

24TH AUGUST, 1894.

At 7.30 a.m. water wash is pumped on . . .	6 tons
„ 1.50 p.m. „ „ „ „ . . .	5 „
Total water wash . . .	11 tons

The tailings are then leached dry and discharged in the morning of the 25th of August.

It takes, therefore, five and a-half days to leach and filter one tank, and the solutions consists of

1. Alkaline wash	10 tons
2. Strong solution	70 „
3. Weak solution	21 „
Total quantity of solution . . .	101 tons

This is by working the Siemens and Halske process.

WORKING SCHEME FOR ONE WEEK AT THE WORCESTER WORKS.

From 20th August to 26th August, 1894.

MONDAY, 20TH AUGUST, 1894.

Tank.	Time. Discharging and Filling.	Time. Discharging and Filling.	Strong Solution. Tons.	Weak Solution. Tons.	Wash Water. Tons.	Remarks.	Volumetric Determination of the Strength of the Solutions.
No. 1	9.15 a.m. 5 tons. 5.40 p.m. 5 " 12.30 a.m. 5 " 6 a.m. to	1 p.m. 5 tons. 9.5 p.m. 5 " 3.30 a.m. 5 " 7 a.m. Water.	70	10 10 10	6		7 a.m. Tank No. 5. Solution contained 0.03 per cent. K. Cy. 11.45 a.m. Tank No. 3. Solution contained 0.010 per cent. K. Cy. 1.25 p.m. Tank No. 3. Solution contained 0.024 per cent. K. Cy. 2.45 p.m. Tank No. 3. Solution contained 0.030 per cent. K. Cy.
No. 2	9 a.m. 5 tons. 6 p.m. 5 " 1.30 a.m. 5 "	1.15 p.m. 5 tons. 9.15 p.m. 5 " 5.15 a.m. 5 "	40 10 10 10				
No. 3	8.50 a.m. 5 tons. 6.10 p.m. 5 " 1 a.m. 5 "	1.25 p.m. 5 tons. 9.25 p.m. 5 "	15 10 10 5				
No. 4	Discharging and Filling. 3.15 p.m. till 6.20 p.m. from No. 3 solution tank. 8.10 p.m. 5 tons. 3.30 a.m. 5 "		10 5	10			
No. 5	Leaching dry.						

SCHEME OF WORKING.

51

TUESDAY, 21ST AUGUST, 1894.

Tank.	Time. Discharging and Filling.	Time. Discharging and Filling.	Strong Solution. Tons.	Weak Solution. Tons.	Wash Water. Tons.	Remarks.	Volumetric Determination of the Strength of the Solutions.
No. 1	Leaching dry.						6.15 a.m. Tank No. 1. Solution contained 0.026 per cent. K. Cy.
No. 2	9.30 a.m. 5 tons.	1.30 p.m. 5 tons.	70	10			8.30 a.m. Strong solution contained 0.050 per cent. K. Cy.
	5.30 p.m. 5 "	9 p.m. 5 "		10			
	12.30 a.m. 5 "	3.20 a.m. 5 "		10	5		10 a.m. Tank No. 4. Solution contained 0.004 per cent. K. Cy.
No. 3	6.10 a.m. to	7 a.m. Water.					11.45 a.m. Tank No. 4. Solution contained 0.008 per cent. K. Cy.
	9.15 a.m. 5 tons.	1.15 p.m. 5 tons.	40	10			2 p.m. Tank No. 4. Solution contained 0.012 per cent. K. Cy.
	4.10 p.m. 5 "	8.50 p.m. 5 "	10	10			5 p.m. Tank No. 4. Solution contained 0.016 per cent. K. Cy.
No. 4	12.40 p.m. 5 "	3.30 a.m. 5 "	10				7.45 p.m. Tank No. 4. Solution contained 0.022 per cent. K. Cy.
	9 a.m. 5 tons.	1 p.m. 5 tons.	15	10			
	5.20 p.m. 5 "	10.15 p.m. 5 "	10	10			9.35 p.m. Tank No. 4. Solution contained 0.028 per cent. K. Cy.
No. 5	3.40 a.m. 5 "		5				10.30 p.m. Tank No. 4. Solution contained 0.03 per cent. K. Cy.
	Discharging and Filling.						
	3.40 p.m. till 7 p.m. from No. 3 solution tank.						
No. 5	8.40 p.m. 5 tons.	10.30 p.m. 5 tons.	10	10			
	3.50 a.m. 5 "		5				

WEDNESDAY, 22ND AUGUST, 1894.

Tank.	Time, Discharging and Filling.	Time, Discharging and Filling.	Strong Solution. Tons.	Weak Solution. Tons.	Wash Water. Tons.	Remarks.	Volumetric Determination of the Strength of the Solutions.
No. 1	Discharging and Filling. 3.50 p.m. till 6 p.m. from No. 3 tank. 8 p.m. 5 tons. 9.45 p.m. 5 tons. 2.40 a.m. 5 "		10 5	10			6.15 a.m. Tank No. 2. Solution contained 0.038 per cent. K. Cy. 7.15 a.m. Tank No. 2. Solution contained 0.032 per cent. K. Cy.
No. 2	Leaching dry.						8 a.m. Strong solution contained 0.054 per cent. K. Cy.
No. 3	9 a.m. 5 tons. 6.20 p.m. 5 " 12 midnight 5 " 6.5 a.m. to 7 a.m. Water.	1.40 p.m. 5 tons. 9.55 p.m. 5 " 3.30 a.m. 5 " 7 a.m. Water.	70 10 10 10	10 10 10	5		10.15 a.m. Tank No. 5. Solution contained 0.010 per cent. K. Cy. 1.30 p.m. Tank No. 5. Solution contained 0.016 per cent. K. Cy. 3.30 p.m. Tank No. 5. Solution contained 0.026 per cent. K. Cy. 4.30 p.m. Tank No. 5. Solution contained 0.030 per cent. K. Cy.
No. 4	9.15 a.m. 5 tons. 6.30 p.m. 5 " 4 a.m. 5 "	1.30 p.m. 5 tons. 9.35 p.m. 5 " 5 "	40 10 10 5				
No. 5	9.30 a.m. 5 tons. 5.20 p.m. 5 " 2.50 a.m. 5 "	1.15 p.m. 5 tons. 9.25 p.m. 5 " 5 "	15 10 10 5				

THURSDAY, 23RD AUGUST, 1894.

Tank.	Time. Discharging and Filling.	Time. Discharging and Filling.	Strong Solution. Tons.	Weak Solution. Tons.	Wash Water. Tons.	Remarks.	Volumetric Determination of the Strength of the Solutions.
No. 1	9.30 a.m. 5 tons. 5.30 p.m. 5 " 12 midnight 5 "	1.25 p.m. 5 tons. 9.35 p.m. 5 "	15 10 10 5				6.30 a.m. Tank No. 3. Solution contained 0.044 per cent. K. Cy. 7.45 a.m. Tank No. 3. Solution contained 0.024 per cent. K. Cy.
No. 2	Discharging and Filling. 4 p.m. to 5.45 p.m. 10 tons from No. 3 tank. 6.45 p.m. 5 tons. 9.25 p.m. 5 tons. 12.10 a.m. 5 "		10 5	10			8.45 a.m. Tank No. 1. Solution contained 0.005 per cent. K. Cy. 12 a.m. Tank No. 1. Solution contained 0.008 per cent. K. Cy.
No. 3	Leaching dry.						4.30 p.m. Tank No. 1. Solution contained 0.016 per cent. K. Cy. 6.15 p.m. Tank No. 1. Solution contained 0.024 per cent. K. Cy.
No. 4	7.30 a.m. 5 tons. 1.50 p.m. 7 " 1.25 a.m. 7 "	7.15 p.m. 7 tons.	65 5	14 7			7.30 p.m. Tank No. 1. Solution contained 0.03 per cent. K. Cy.
No. 5	9.15 a.m. 5 tons. 2.20 p.m. 5 " 12.20 a.m. 5 "	1.40 p.m. 5 tons. 9.15 p.m. 5 " 3.30 a.m. 5 "	40 10 10 10				8.30 p.m. Strong solution 0.054 per cent. K. Cy.

FRIDAY, 24TH AUGUST, 1894.

Tank.	Time. Discharging and Filling.	Time. Discharging and Filling.	Strong Solution. Tons.	Weak Solution. Tons.	Wash Water. Tons.	Remarks.	Volumetric Determination of the Strength of the Solutions.
No. 1	9.40 a.m. 5 tons.	1.15 p.m. 5 tons.	40				4.30 a.m. Tank No. 4. Solution contained 0.064 per cent. K. Cy.
	5.20 p.m. 5 "	9.20 p.m. 5 "	10				6.30 a.m. Tank No. 4. Solution contained 0.064 per cent. K. Cy.
	12.30 a.m. 5 "	3.30 a.m. 5 "	10				7.45 a.m. Tank No. 4. Solution contained 0.065 per cent. K. Cy.
No. 2	9.55 a.m. 5 tons.	1.30 p.m. 5 tons.	15				11.15 a.m. Tank No. 4. Solution contained 0.046 per cent. K. Cy.
	5.30 p.m. 5 "	9.30 p.m. 5 "	10				12.30 p.m. Tank No. 4. Solution contained 0.044 per cent. K. Cy.
	5.45 a.m. 5 "		5				3 p.m. Tank No. 4. Solution contained 0.046 per cent. K. Cy.
No. 3	Discharging and Filling.			10			4.30 p.m. Tank No. 4. Solution contained 0.046 per cent. K. Cy.
	3.15 p.m. to 5.50 p.m. from No. 3 tank.		10				10 p.m. Tank No. 4. Solution contained 0.042 per cent. K. Cy.
	7.20 p.m. 5 tons.	9.45 p.m. 5 tons.	5				8.45 p.m. Strong solution contained 0.054 per cent. K. Cy.
No. 4	7.30 a.m. to 8.30 a.m. 6 tons. Water.		70	21	6		12.5 a.m. Tank No. 4. 0.036 per cent. K. Cy.
	1.50 p.m. Leaching dry.				5		
No. 5	10.10 a.m. 5 tons.	1.45 p.m. 5 tons.	70	10			12 p.m. Tank No. 2. Solution contained 0.026 per cent. K. Cy.
	5.40 p.m. 5 "	10 p.m. 5 "		10			2.10 p.m. Tank No. 2. Solution contained 0.035 per cent. K. Cy.
	1 a.m. 5 "	4.25 a.m. 5 "		10			
	6 a.m. to 7.45 a.m. Water.				5		

SATURDAY, 25TH AUGUST, 1894.

Tank.	Time. Discharging and Filling.	Time. Discharging and Filling.	Strong Solution. Tons.	Weak Solution. Tons.	Wash Water. Tons.	Remarks.	Volumetric Determination of the Strength of the Solutions.
No. 1	8.30 a.m. 5 tons. 6 p.m. 5 "	1.15 p.m. 5 tons. 8.30 p.m. 5 "	70	10			6.45 a.m. Tank No. 5. Solution contained 0.046 per cent. K. Cy.
	11.30 p.m. 5 "	3.10 a.m. 5 "		10			7.45 a.m. Tank No. 5. Solution contained 0.042 per cent. K. Cy.
	5 a.m. to 6 a.m. 6 tons.	7.30 a.m. to 8.10 a.m. 4 tons. Water.		10	10		10 a.m. Tank No. 5. Solution contained 0.034 per cent. K. Cy.
No. 2	9 a.m. 5 tons. 3.35 p.m. 5 "	1 p.m. 5 tons. 9.5 p.m. 5 "	40				9.30 a.m. Tank No. 4. Solution contained 0.026 per cent. K. Cy.
	11.45 p.m. 5 "	4.30 a.m. 5 "	10				8 a.m. Strong solution contained 0.060 per cent. K. Cy.
			15				
No. 3	8.15 a.m. 5 tons. 5.45 p.m. 5 "	12 noon. 5 tons. 9.15 p.m. 5 "	10				8.15 a.m. Tank No. 3. Solution contained 0.008 per cent. K. Cy.
	12.45 a.m. 5 "		5				10.45 a.m. Tank No. 3. Solution contained 0.010 per cent. K. Cy.
							12.30 a.m. Tank No. 3. Solution contained 0.013 per cent. K. Cy.
No. 4	Discharging and Filling.			10			2.30 p.m. Tank No. 3. Solution contained 0.020 per cent. K. Cy.
	6 p.m. till 8.15 p.m. from No. 3 tank. 10.5 p.m. 5 tons	1 a.m. 5 tons	10				4.30 p.m. Tank No. 3. Solution contained 0.033 per cent. K. Cy.
	4.30 a.m. 5 "		5				
No. 5	Leaching dry.						

SUNDAY, 26TH AUGUST, 1894.

Tank.	Time. Discharging and Filling.	Time. Discharging and Filling.	Strong Solution. Tons.	Weak Solution. Tons.	Wash Water. Tons.	Remarks.	Volumetric Determination of the Strength of the Solutions.
No. 1	Leaching dry.						6.40 a.m. Tank No. 1. Solution contained 0.05 per cent. K. Cy.
No. 2	9.40 a.m. 5 tons.	1.15 p.m. 5 tons.	70	10			8.15 a.m. Tank No. 1. Solution contained 0.042 per cent. K. Cy.
	5.30 p.m. 5 "	9.30 p.m. 5 "		10			9.30 a.m. Tank No. 1. Solution contained 0.035 per cent. K. Cy.
	12.30 a.m. 5 "	3.45 a.m. 5 "		10	6		8.15 a.m. Strong solution contained 0.056 per cent. K. Cy.
No. 3	9.25 a.m. 5 tons.	1 p.m. 5 tons.	40				11.15 a.m. Tank No. 4. Solution contained 0.008 per cent. K. Cy.
	5.5 p.m. 5 "	9.20 p.m. 5 "	10				2.30 p.m. Tank No. 4. Solution contained 0.016 per cent. K. Cy.
	12.35 a.m. 5 "	3.30 a.m. 5 "	10				4.15 p.m. Tank No. 4. Solution contained 0.028 per cent. K. Cy.
No. 4	9.10 a.m. 5 tons.	12.45 p.m. 5 tons.	15				5.15 p.m. Tank No. 4. Solution contained 0.034 per cent. K. Cy.
	5.15 p.m. 5 "	9.10 p.m. 5 "	10				
	12.20 p.m. 5 "		5				
No. 5	Discharging and Filling.						
	5.30 p.m. till 8.20 p.m. from No. 3 tank.			10			
	9 p.m. 3 tons.	10 p.m. 3 tons.		6			
	11 p.m. 4 "	3.15 p.m. 3 "		4			
	2.10 p.m. 3 "			6			

CHAPTER IV.

PARTICULARS OF OPERATIONS AT VARIOUS WORKS.

Crown Reef Works.—At these works* the tailings undergo the following treatment by the direct process.

The 120 stamp battery crushes on an average 17,000 tons of ore monthly. Of this quantity, 12,000 tons of tailings go to the cyanide works, which assay from 4 to $4\frac{1}{2}$ dwts. The slimes, amounting to 5,000 tons, assaying $3\frac{1}{2}$ dwts., go to the reservoirs.

The tailings from the battery pass through 3 spitzluten, one placed in front of the other, and here a classification of the tailings is effected. From the spitzluten the stream is divided and passed to the separators or spitzkasten, of which there are four, placed in front of the leaching-tanks. At the bottom is a T-piece, with a nozzle screwed on either side, and a rubber hose, the discharge of which can be regulated by a clamp, so that the stream can be diverted into one or the other of the tanks. Mr. Williams claims that he eliminates more slimes by this system of direct filling, and that the tailings which he retains are richer. He claims that 70 tons of his tailings contain more gold than 75 tons of tailings saved by the intermediary tanks, and that is the reason why he discarded them. According to these figures he saves the treatment of 855 tons of tailings every month.

From the spitzkasten the tailings discharge into six large cement filter-tanks, each 40 ft. from front to back, 34 ft. wide, and 10 ft. high, measured inside the tank. At the bottom the

* For the information in regard to these works I am indebted to Mr. Williams, the chemist in charge.

tanks are narrower, as the inside is built of sloping walls. The side walls are 4 ft. thick at the bottom and 18 in. at the top. Their capacity when full is about 500 tons of tailings.

The sides and walls are of brickwork set in hydraulic lime, and plastered with cement plaster. The bottom is of cement concrete at least 12 in. thick. The concrete is made up of three parts of treated tailings sifted, five parts broken stone down to 2 in. cube, and one part of Portland cement. It is mixed, put in place, rammed, and levelled up with a grout mixed two of sand and one of cement. The bottom of the cement-tank slopes to a central gutter, having a 2-in. fall from the front and back to the centre, where a gutter, 4½ in. wide, starts at the division walls of the tank with a fall of 4 in. towards the centre, where is a small pit 15 × 15 in. and 12 in. deep, formed in the cement bottom, connected with a 4-in. pipe bedded in the concrete, and through which the 2½-in. solution pipe is threaded.

The filter bottom averages 5 to 6 in. in thickness, and is made by filling in with broken stone a 3 by 3 in. wooden combing, laid in cement mortar and bolted to the bottom of the tank all round. Over this is laid the filter-cloth.

Each tank is provided with three iron gates, through which the residues are trammed to the dump. Each gate is suspended by a vertical pulley from a horizontal axle running on wheels, which roll to and fro on rails running on the top of the wall on either side of the door.

A cast-iron frame is built into the brickwork round the doorway, and the door made water-tight by wedging against rubber packing. Inside the filter-tanks are laid three 18-in. tramway tracks on longitudinal sleepers, which remain in the filter, and are only removed when the filter-cloth is to be raised. In the doorway is fitted a short piece of rail composed of 2 in. square iron, provided with pins projecting from its lower surface, which pins are dropped into holes in iron plates fitted on the sills inside and outside the doorway. This piece of rail is removed when it is necessary to open the door. To still further reduce the quantity of slimes treated, there are

slime gates in the tanks. These are between the doors of the tanks, and are simply a series of wooden slats about 4 in. wide, sliding in a vertical groove $2\frac{3}{4}$ in. from the wall of the tank. During the filling of the tank with tailings, any slimes which remain in suspension flow over into this sluice-gate, which is raised by additional slats as the tanks fill higher and higher, and pass away by a 4-in. drain-pipe to the reservoir.

Even distribution of the tailings of the tanks is effected by constantly moving the nozzle of the charging hose.

Any leakage of cyanide from the doors of the tanks is provided for by a gutter 6 in. wide being formed in the concrete, outside the wall, and about 12 in. from it. This, starting at one end of the row of tanks, falls about 12 in. in its total length, and terminates in a small brick water-tight tank, 2 ft. square by 2 ft. 6 in. deep, from which a pipe leads to the extractor-house.

The solution drainage pipes are $2\frac{1}{4}$ in. in diameter, and, until outside the tanks, are threaded through a 4-in. pipe.

The tailings are under treatment for 102 hours. Each tank of 500 tons gets about 400 tons of solutions and washes.

The strong solution contains 0.3 per cent. K Cy

The weaker solution contains 0.15 per cent. K Cy

The weakest solution contains 0.05 per cent. K Cy

The final wash water amounts to 25 tons.

The treatment in the leaching-vats is as follows :—It takes 30 hours to fill one of these vats. No. 3 vat, for instance, holds 550 tons of tailings. Say at 12.30 on the 29th August, 50 tons of 0.05 per cent. of cyanide solution is run on to drive out the water. When the solution is run through 75 tons of strong solution, 0.3 per cent. is put on. On the 30th August, 75 more tons of 0.3 per cent. is put on. On the 31st August, 65 tons of 0.15 per cent. is put on. From the 1st to the 3rd September, 300 tons of 0.05 per cent. solution, inclusive of 25 tons of wash water, are put on. Altogether the treatment takes 6 days, the total quantity of solution employed being 565 tons for this particular tank, in which the tailings assayed $5\frac{1}{4}$ dwts.

and the residues 1.1 dwts. An extraction of 80 per cent. was obtained, which is rather above the average.

The quantity of tailings treated in each tank is tallied by counting the number of trucks which are discharged. From the leaching-vats the solution runs to the extractor-house, where there are three large stock solution-tanks excavated in the ground, brick-lined and cemented, and of the same dimensions as the lixiviation tanks.

Into No. 1 tank are run all solutions up to 0.08 per cent. K. Cy., which makes up an average of 0.05 per cent. with the weaker solutions.

No. 2 tank receives all solutions from 0.08 to 0.2 per cent. K. Cy., making up an average of 0.15 per cent. K. Cy.

No. 3 tank receives everything from 0.2 per cent. upward, and is made up to 0.3 per cent. by adding extra strong solution from the dissolving tank, and the same is agitated by means of a circulating pump.

There is also a vacuum well, consisting of two cylindrical iron receivers connected to an air-pump, in order to create a vacuum in case the filter is stopped up, or when it is necessary to assist percolation, or when it is necessary to dry the ore before discharging.

From the stock solution-tanks centrifugal pumps take the solution either from one or the other, and pump it into the filter-tanks. Before the solution passes into the extractor-boxes, the same flows into three small wooden tanks, where any impurities settle.

At this mine 50 to 60 per cent. of the gold leaving the battery is obtained in the cyanide works. The consumption of cyanide is claimed to be $\frac{1}{2}$ lb. per ton treated and $4\frac{1}{2}$ oz. zinc per ounce of gold won. The works produced 2,914 oz. gold in August, 1894. The works are nicely planned and splendidly constructed, and the mechanical details have been, no doubt, under the supervision of a skilled man, and may be considered as one of the fine plants on the gold-fields, but they gave me the impression that their cost of erection must be far in excess of those plants which use wooden tanks.

Simmer and Jack Works.—When these works were erected the Company had a large accumulation of tailings, the results of five or six years' working, crushing first with 50 and afterwards with 100 stamps.

A contract was entered for the treatment of 100,000 tons with the Rand Central Ore Reduction Company, and under the direction of Mr. Butters, one of the finest and best plants on the gold fields was erected within three months. While in Johannesburg, I made this plant the special object of my study, and I am indebted to Messrs. Torrente and Smart, the chemists in charge, for some of the working details here given, as well as for the illustrations of the works given in Plates VIII., IX., X.

The plant has a capacity to treat 600 tons tailings daily, and consists of five vats of 600 tons capacity each ; three stock solution storage-tanks of 300 tons capacity each ; building containing four precipitation-boxes ; three 2-in. centrifugal pumps, for returning the solutions from the precipitation-boxes to the storage-tanks ; one 4-in. centrifugal pump, for pumping the solutions from the storage-vats to the leaching-vats ; two lathes for cutting the zinc shavings ; engine to work lathes and pumps and a 60 horse-power boiler to supply steam to engine, and two hauling gears.

There is stabling, also, for 40 mules ; besides a large compound to house 200 Kaffirs, a manager's house, and 6 rooms for the white employees.

The tailing vats are 42 ft. in diameter and 14 ft. high, firmly bound with iron hoops 1 in. thick. It takes 10 to 11 hours to fill each vat.

The zinc boxes, four in number, are placed in a building which also encloses the stores, office, engine, lathes, and boiler. They are 24 ft. long, 3 ft. 6 in. broad, 2 ft. 6 in. deep. They are divided in 13 compartments. In every compartment there is a tray with a sieve of 20 to 25 holes to the inch at the bottom, on which the zinc shavings are loosely placed till they reach within 6 in. of the top of the boxes. The trays reach within 4 in. of the bottom of the boxes, this space being

left to collect the slimes resulting from the precipitation of the gold on the zinc. The compartments are divided from each other by two boards, the one reaching to the bottom of the box, and the other within $3\frac{1}{2}$ in. This ensures the greatest amount of contact of the solution with zinc, and therefore an almost perfect precipitation.

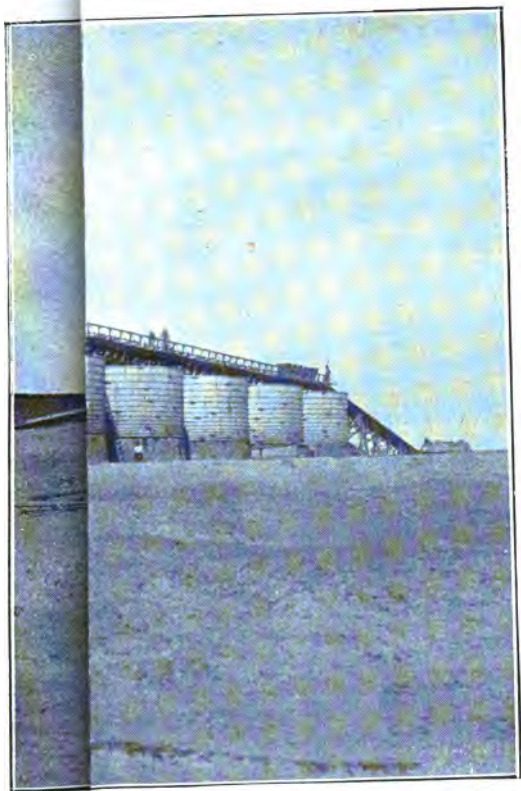
A 4-in. centrifugal pump is used to run the solutions from the storages into the tailing vats, and three small 2 in. centrifugals, return the solutions from the zinc boxes into their respective storages. A donkey pump is used for cleaning the zinc boxes, and three small tanks, called the clean-up tanks, which are used to settle the zinc slimes.

Working of the Plant.—I shall here restrict myself to the actual manipulation of the solutions. The process as carried out at the Simmer and Jack works has to deal (1) with old tailings containing acid ; (2) with the tailings coming daily down from the mill, where they keep a certain number of stamps working on free-milling ore (oxidized), and the remainder on pyritic material (blue rock).

The quicklime is ground in a ball mill, constructed by the Gruson works, in Magdeburg, and in every truck of tailings a certain quantity is put, in proportion to the amount of the free acid therein contained.

A good practical way of ascertaining this is to take a given quantity of tailings, say 1 kilo., and place them in an enamelled bucket or basin, adding two or three times their weight in water. Leave them there for two or three hours, occasionally stirring the same, and the blue litmus paper will show if any acid is present. Given the presence of acid : take a weighed quantity of quicklime, finely ground (say 50 grms.), and with a spoon throw a small quantity in the vessel containing the tailings, stirring the same all the time, and keep on adding lime, little by little, until the red litmus paper turns slightly blue, when the acid will be neutralized. By weighing again the remaining lime, the quantity used will be known, and if, say 2 grms. has been used, we shall have that—

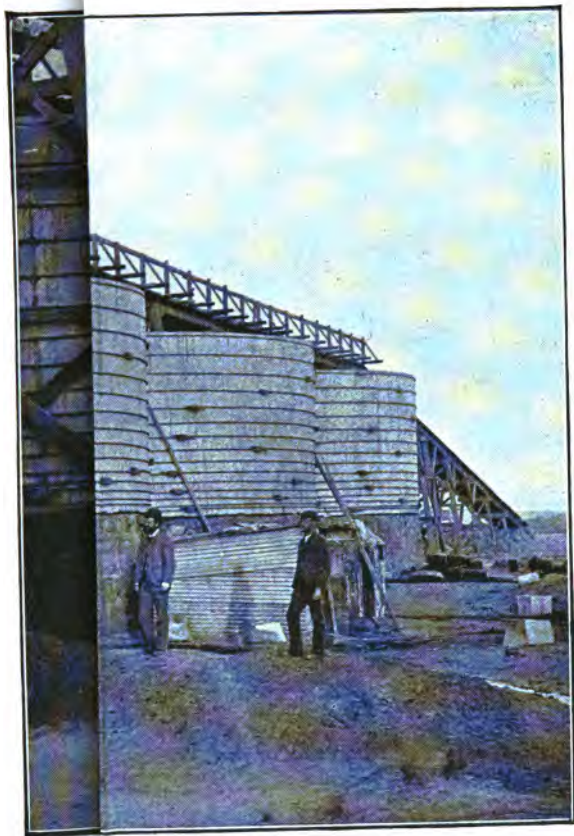
PLATE VIII.



Cyanide Plant.

[To face p. 62.]

PLATE IX.



ats.

[To face p. 62.

If 1 Kg. takes 2 grms. of lime
1,000 Kgs. (1 ton), will require 1,000 times more, or
2,000 grams, which is equal to 2 Kgs.

Now, if every truck carries, say, $\frac{1}{2}$ ton of tailings, it will require 1 kilo. of lime, or 2·12 English lbs. The advantage of supplying every truck with its proper quantity of lime, is to ensure its even distribution through the mass in the vat.

When the vat is full, it is carefully levelled, and then is ready to be treated.

In the case when lime has been used, the tank is filled with water and allowed to stand full for one hour. By this time the acid has been neutralized, and it can be started leaching. The water from the leaching carries, as a rule, a small excess of alkali, and it is pumped back into one of the storages, to be used again in the next tank. To this water the name of alkaline solution, or caustic wash, is given; and, as a rule, the moisture in the tailings is enough to keep the amount in hand constant, so that very seldom is it necessary to add any more water to it. It is necessary to keep the solution in a storage tank, so as to avoid any loss of gold, as it always carries with it whatever gold may have been left in the filters, &c., from previous treatment. It will also be found that, after treating a few tanks, the solution will contain a small percentage of cyanide.

When the caustic wash is partly drained off, the top of the tailings are turned over with a shovel, so as to break the slimy film which forms; and then follows the solution, whose quantity must be so regulated as to give about $\frac{1}{4}$ lb. of cyanide (or less) per ton of tailings, and be of a strength of ·25 to ·3 per cent.

This solution is followed by another, which is called weak solution, and whose strength varies between ·08 and ·15 per cent. of cyanide, and is kept on until the tank is ready to leach dry.

Should the solution in the storages get short, a water wash is given to terminate the operation: otherwise the weak solution is used to the last.

The system followed in pumping up the solutions is to keep the tanks always well covered up from the moment the strong solution is first pumped up. As soon as the tailings show, more solution is added until the full amount has been pumped up. This is followed at once with a weak solution, which, in its turn, must keep the tailings always well covered till the tank is ready to water wash or leach dry.

The time employed in these diverse operations is about as follows:—

1st. *Caustic Wash (water or otherwise).*

Pumping	3 hours
Contact	1 hour
Leaching	8 hours

2nd. *Strong Solution.*

Is pumped without stopping the leaching until all is on,	
takes about	8 hours
(Amount used about 160 tons.)	

3rd. *Weak Solution.*

Is kept up circulating as previously explained about . . .	40 hours
--	----------

4th. *Water Wash (if necessary).*

Leach dry	24 hours
Time it took to load tank	12 "

Total from the time of starting filling till ready to discharge 96 hours

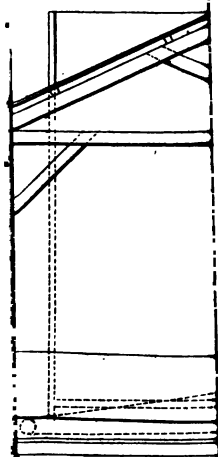
(Total amount of strong and weak solution between 500 and 600 tons.)

Precipitation of the Gold from the Solution.—From the bottom of the tailing tanks, and under the filter, a pipe 2 in. in diameter carries the solution to the zinc boxes, four in number, as already mentioned.

The object of these four zinc boxes is to return the solutions to their respective storages, for which purpose they are connected:—

- 2 with the strong solution storage,
- 1 with the weak solution storage,
- 1 with the caustic wash storage.

A simple assay will show to the man in charge when to lead



8.



the leachings through the one or through the other box. The boxes have a fall of 9 in. in their full length.

Recovery of the Gold from the Gold Slimes.—The gold slimes are settled in the slime-tank by means of alum or sodium sulphide. After 12 hours the clear portion is syphoned down, and these slimes are then ready for further treatment. The test of the sodium sulphide is lead paper, which takes a brownish colour when the residues in the tank have been saturated.

To make sodium sulphide :—

6½ gals. water,
62½ lbs. caustic soda,
41 lbs. sulphur (broken small).

Boil the water with the soda till dissolved, and then add the sulphur slowly, as it is apt to boil over. Dilute to 40 gals. Smaller quantities in proportion.

The slimes are transferred to a special calcining furnace, where they are dried and the zinc slightly oxidized. They are left to roast at a dull red heat for 4 hours, although this time depends upon the quantity and nature of the slimes. After roasting, they are put into iron dishes and mixed with the smelting fluxes.

To 6 shovels of slimes add—

½ shovel flour spar,
3 shovels borax,
1 shovel carbonate of soda.

If the slimes are hard, and cake, they must be ground fine so as to mix them well with the fluxes.

If the fire gets too fierce while smelting the slimes, and the pots overflow, keep the cover off, and throw a little borax on the top. This overflowing is objectionable, as the slag cakes at the bottom of the grate and chokes the fires. When all the

gold belonging to one lot of slimes has been secured, it is then melted down into one bar.

Langlaagte Estate.—At these works, the pulp on leaving the mill passes into three settling-dams in rotation. The lower retaining walls are composed of sand-bags, and two doors are provided in each dam, one for the passage of the full, and the other for the empty trucks.

The discharge of the slimes, when filling the dams, is regulated by strips of wood in the passages, the same system being employed at the Randfontein Estate. Lines of rails are placed inside these dams; and at right-angles to these, immediately inside the lower walls, runs a line of rails sunk in the ground, on which is placed a travelling-carriage, on to which the tipping trucks are run and brought outside the dams, to be picked up by a mechanical haulage composed of an endless wire rope, and carried to the cyanide works.

Here are ten vats sunk in the ground, five on each side, and when the tailings are treated they are emptied by means of a travelling crane, which lowers the body of 25 cubic feet capacity trucks into the vats, to be filled by Kaffirs, and are then lifted out again and placed on their respective carriage, and conveyed by mechanical haulage to the waste dumps. A vat can be emptied in six hours.

The mechanical haulage is operated by a 25 n.h.p. compound engine, with 24-in. stroke and 25 h.p. boiler, consuming about 1½ tons coal per day.

Rand Central Ore Reduction Company.—A prominent position in the treatment of tailings and concentrates is occupied by the above Company, which was organised by Mr. Ad. Goerz, Mining Engineer, representing a powerful German syndicate. The Company, who own the Siemens and Halske patents for South Africa, have bought over 1,000,000 tons of tailings, of an average value of 4½ dwts., and 6,173 tons of concentrates, of an average assay and contents of about 4 oz. The technical work is directed by Mr. Charles Butters.

The establishments of the Company are six in number, and include (1) their central works (shown in Plate XI.)—consisting of a chlorination plant and cyanide works, with workshops and foundry, where everything is made for vats, implements, etc., required for the construction of cyanide plants; (2) works at Maraisburg, which were built to treat tailings from the Main Reef, Aurora, and Aurora West Companies; (3) the Simmer and Jack works, already described; (4) the Worcester works, already described; (5) the No. 1 works, which treat tailings from the Pioneer Company; and (6) the No. 2 works, which treat tailings from the United Langlaagte.

During the year ending June 30th, 1894, the Company treated at their six works 311,561 tons of tailings, yielding 52,434·46 oz., of a value of £209,737 16s. 8d.

Dry Crushing.—As proper percolation of the solution can only be obtained by having the pulp coarse enough to allow of easy leaching, several establishments in the United States have adopted dry crushing.

Mr. Philip Argall, M.R.I.A. (see *Mining Journal*, London, October 13th, 1894), says: "The best results hitherto obtained on rather friable oxidized siliceous ores have been produced by the following series of machines:—

"(a) An ordinary Blake crusher, which reduces the ore to about $1\frac{1}{2}$ in.;

"(b) A three-jaw multiple Blake crusher, which brings the ore down to $\frac{3}{4}$ in.; followed by

"(c) A five-jaw multiple, that reduces it to about 6 mesh; and

"(d) Rolls that finish the pulp to pass a 30 mesh screen.

"The ore is screened after each crushing, so that the portion reduced to the desired fineness passes direct to the finished ore-bin, instead of, as is too often the case, going to the next machine to be reduced to a further and unnecessary degree of fineness. This plant, crushing to 30 mesh, produces only from 5 to 10 per cent. fine enough to pass 200 mesh.

"With soft, clayey ore, from 5 to 15 per cent. of the

finest dust has to be removed before a leachable product is obtained."

The preparation of the ore, in dry as well as in wet crushing, is a very important step in the direct treatment by the cyanide process, and the latter has only been brought to its present state of perfection within the last six months. Owing to the scarcity of water in West Australia, I believe that many mines will have to adopt dry crushing plants, and that the system will reach there a high degree of perfection.



ompany.

[To face p. 68.]



CHAPTER V.

*THE CHEMISTRY OF THE CYANIDE PROCESS.**

Solution of the Gold.—The solubility of gold in a solution of cyanide of potassium has long been known. The presence of oxygen is necessary for the reaction, after the formula :



That is, a double cyanide of gold and potassium is formed. This was proved by the formation, upon evaporating the solution, of octahedral crystals answering to the formula. From the solution the gold is precipitated by filiform zinc. Based on these two reactions, the MacArthur-Forrest Company have obtained the following patent:—

“The invention consists in subjecting the auriferous or argenterous ores to the action of a solution containing a small quantity of cyanide, as hereinafter set forth, without any other chemically active agent, such quantity of cyanide being reckoned according to its cyanogen, and the cyanogen being proportioned to the quantity of gold or silver, estimated by assay or otherwise to be in the ores under treatment. By treating the ores with the dilute and simple solution of a cyanide, the gold or silver is, or the gold and silver are, obtained in solution, while any base metals in the ores are left undissolved, except to a practically inappreciable extent ;

* The chemistry of the process has been described by Messrs. Butters and Clennell in the *Engineering and Mining Journal* of October 22nd and 29th, 1892, and from their articles (with their permission) this matter is extracted.

whereas when a cyanide is used in combination with an electric current, or in conjunction with another active chemical agent—such as carbonate of ammonium, or chloride of sodium, or phosphoric acid—or when the solution contains too much cyanide, not only is there a greater expenditure of chemicals in the first instance, but the base metals are dissolved to a large extent along with the gold or silver, and for their subsequent separation involve extra expense, which is saved by our process.

“In carrying out our invention practically, we take the ore in a powdered state and mix with it the solution of cyanide in a vessel made of, or lined with, any material not appreciably acted on by the solution. . . . We regulate the quantity of cyanide so that its cyanogen will be in proportion to the quantity of gold or silver in the charge of ore; but in all cases we dissolve it in sufficient water to keep the solution extremely dilute, because it is when the solution is dilute that it has a selective action, such as to dissolve the gold or silver in preference to the baser metals.

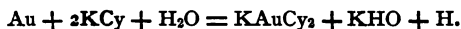
“In dealing with ores containing 20 oz. or less of gold or silver, or gold and silver, per ton, we find it most advantageous to use a quantity of cyanide, the cyanogen of which is equal in weight to from 1 to 4 parts for every 1,000 parts of the ore, and we dissolve the cyanide in a quantity of water of about half the weight of the ore. In the case of richer ores, while increasing the quantity of cyanide to suit the greater quantity of gold or silver, we also increase the quantity of water so as to keep the solution dilute. In other words, the cyanide solution should contain from 2 to 8 parts, by weight, of cyanogen to 1,000 parts of water, and the quantity of the solution used should be determined by the richness of the ore. After the solution has been decanted or separated from the undissolved residues, the gold and silver may be obtained from it in any convenient way, such as evaporating the solution to dryness and fusing the resulting saline residue, or by treating the solution with sodium amalgam.

“Having fully described our invention, what we desire to

claim and secure by letters patent is : The process of separating precious metals from ore containing base metal, which process consists in subjecting the powdered ore to the action of a cyanide solution containing cyanogen in the proportion not exceeding 8 parts of cyanogen to 1,000 parts of water."

Some time after this patent was issued, patents covering the use of zinc, preferably filiform, or threadlike, for a precipitating agent, and the use of caustic alkalies for neutralizing ores containing acids, or acid salts, were granted to Messrs. MacArthur and Forrest. It will be seen, therefore, that their patents cover substantially three points : namely, the use of dilute solutions of cyanide (not more than 8 parts of cyanogen to 1,000 parts of water) ; the use of zinc, preferably filiform, as a precipitant ; and the employment of caustic alkalies for neutralizing acid ores.

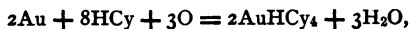
Mr. Louis Janin claims,* that the necessity of oxygen in the reaction which takes place in the solution of the gold in the cyanide has not been proved, and establishes the following formula :—



More recent investigation has proved that oxygenation of the gold in the process is essential to its success, and the idea has been suggested that an artificial oxygenation of the gold in rebellious ores may lead to the solution of the problem of treating them successfully by the cyanide process.

Mr. R. Feldtmann, in his "Notes on Gold Extraction," gives the following additional formulæ, throwing light on the reactions which take place in the solutions of gold in cyanide :—

When hydrocyanic acid dissolves gold from acid tailings (assuming that the cyanide has destroyed all the cyanide of potassium),

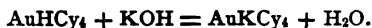


an auric hydrocyanide is produced, and this compound is not, or is at any rate only imperfectly, precipitated by zinc. Even rendering the solution alkaline by addition of caustic soda or potash, does not appear in such a case to cause a good precipi-

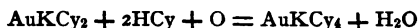
* *Mineral Industry*, 1892. Scientific Publishing Co., New York.

tation. This may be owing simply to the auric compound being more stable than the aurous salt ordinarily obtained, or may be owing to the absence of free cyanide of potassium.

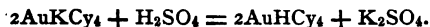
The addition of alkali to such a solution of auri cyanic acid may be assumed to form auric potassic cyanide in this way :—



The addition of an acid to working solutions containing free potassic cyanide, and a certain amount of auro potassic cyanide, would appear—probably indirectly—to convert at least a portion of the latter into auri cyanic acid. Probably the hydrocyanic acid, liberated by the decomposition of the potassic cyanide, combines with the auro potassic cyanide to form auri potassic cyanide :—



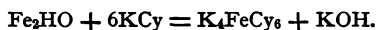
which, in its turn, acted on by the mineral acid, is converted into auri cyanic acid :—



Solubility of other Metals and Minerals.—According to Gmelin, zinc, iron, nickel, and copper are dissolved by potassium cyanide, with evolution of hydrogen; cadmium and silver in the presence of oxygen; and tin, mercury, and platinum not at all. Sulphide of silver is dissolved by strong solutions and a sufficient quantity of weak solution. Silver arsenate $\text{Ag}_3 \text{As O}_4$, and silver antimonate AgSbO_3 are readily dissolved by potassium cyanide, as are many of the argentiferous arsenical and antimonial minerals found in nature. Chloride of silver dissolves readily, forming chloride of the alkali and a double cyanide of silver and potassium. While metallic silver, when sufficiently fine, dissolves readily in the solution, that found native in ores is not attacked, unless existing in thin laminæ. The oxides and sulphides of copper are attacked by the solution and dissolved, as is metallic copper.

It is claimed that the presence of copper sulphide in a silver or gold ore prevents the precious metals from going into solu-

tion. Although experiments have shown that little or no silver or gold is dissolved in certain ores containing sulphide of copper, this question is by no means settled, as artificially-prepared sulphide of silver is dissolved in actual contact with the copper compounds. Metallic iron is attacked, but very slowly. Ferric hydrate is not attacked by the solution, but ferrous hydrate, formed in the neutralization of the iron salts by alkali, is attacked by cyanide, according to the reaction :—



Thus ferrocyanide of potassium and caustic potash is formed.

Louis Janin's Experiments on Silver Ores.*—Mr. Janin made a series of experiments on the applicability of the cyanide process to various types of ores, with the following results :—

Sample No. 1.—Grand Central Mine, Arizona. Siliceous ores, containing considerable quantities of lime and manganese. The silver minerals are principally cerargyrite and argentite, and gave an extraction of 92·6 per cent.

Sample No. 2.—Christy Mine, Silver Reef, Utah. The silver minerals are chlorides, sulphides, metallic silver, in a gangue of sandstone, somewhat discoloured by carbonate of copper. Extraction, 80 per cent.

Sample No. 3.—Horn Silver Ore, Utah. The silver principally as chloride. Extraction, 93 per cent.

Sample No. 4.—Tybo, Nevada. The mineral is principally a sulphide and fahlore. Extraction, 71·8 per cent.

Sample No. 5.—Gangue siliceous with chloride of silver. Extraction, 97 per cent.

Sample No. 6.—Ramshorn, Idaho. Containing galena and carbonate of lead, pyrites, and zinc blende. Extraction, 80 per cent.

Sample No. 7.—Broken Hill, New South Wales. Chloro bromide of silver in kaolin, quartz, and garnet. Extraction, 99·7 per cent.

* From *Mineral Industry*. The Scientific Publishing Co., New York.

Sample No. 8.—Broken Hill, New South Wales. A siliceous iron ore containing 38 per cent. Fe O. Extraction, 84·6 per cent.

Sample No. 9.—Bullionville, Nevada. Tailings, containing 10 per cent. carbonate of lead, galena, and iron in a siliceous gangue. Extraction, 32 per cent.

Sample No. 10.—Bertrand and Geddes, Nevada. Contains antimoniate of lead, with which the silver was combined. Extraction, 11·8 per cent.

Sample No. 11.—Argenta, Montana. Contains over 40 per cent. lead. Extraction, 5·7 per cent.

Sample Nos. 12 and 13.—Belmont, Nevada. Contains arsenical pyrites, pyrite, blende, and galena, with the silver as fahlore, and arsenical and antimonial ruby forms. Extraction, 35 and 47·5 per cent.

Sample No. 14.—Las Yedras, Mexico. Contains large quantities of carbonate of lime, with the silver in the form of ruby silver, and arsenical pyrites. Extraction, 41·5 per cent.

Sample Nos. 15 and 16.—Ontario and Daly ores, Utah. Contain principally fahlore, more or less decomposed with some lead and zinc. Extraction, 72·5 and 81·1 per cent.

The conclusions and deductions to be derived from a study of the foregoing are, that silver in oxidized surface ores, or where it occurs as a chloride, is readily attacked by cyanide of potassium, and that where no minerals are present which exert an unfavourable influence, this method may prove economical. It must be confessed, however, that even with these conditions it has but a limited range of usefulness. On the other hand, where lead, oxide of copper, or oxides of iron occur, the results are so poor as to preclude the use of the process.

The results obtained from different samples of silver ore from the same mine vary greatly, for a slight increase of an undesirable element, which would not affect amalgamation in the slightest degree, causes a great decrease in the percentage of extraction by cyanide.

In the case of a number of experiments on Daly ores, the

results varied 16.2 per cent., while, with amalgamation, there was a variation of but 2 per cent.

Results of Experiments made with Potassium Cyanide on Gold and Silver Ores.—It would seem probable that, in ores containing both gold and silver, only the oxidized surface ores can be treated with success, both the silver and gold minerals from depth proving refractory. With the majority of these ores the consumption of cyanide would be large, as many minerals other than those of silver are contained in them, and would have a decomposing action upon the solution.

Experiments on Gregory concentrates, consisting of pyrites, some arsenopyrite and chalcopyrite, with traces of galena and blende, gave an extraction of 90 per cent. gold and only 3 per cent. silver.

Delamar, Idaho, consisting of a siliceous and limestone gangue, impregnated with silver sulphides and chlorides, and iron pyrites. Results: gold, 90 per cent.; silver, 83 per cent.

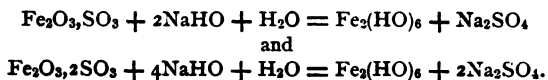
Revenue Mine, Montana—Oxidized surface ores, containing a considerable quantity of iron. Gold, 94 per cent.; silver, 5.2 per cent.

Southern Cross, Montana, contains 40 to 50 per cent. of limonite. Gold, 93 per cent.; silver, 50 per cent.

I am not aware, so far, that the cyanide treatment has been applied on a large scale to the extraction of silver ores.

Treatment of Pyritic Ore Previous to Lixiviation with Cyanide.—Pyritous ore, if but slightly exposed to atmospheric action, always contains free sulphuric acid and soluble salts of iron. To prevent reactions on the solution, it is necessary to leach these ores with water previous to lixiviation with cyanide of potassium, and before washing with an alkali. If the alkali solution were to be added directly to the ore, the consumption of alkali would be extremely large, and the amount of solution necessary, if lime were to be used, would prove inconvenient to handle.

The alkali solution, assuming that caustic soda is used, reacts on basic iron salts, insoluble in water, according to the following reactions :—



Thus ferric hydrate and sodium sulphate (or calcium sulphate, if lime is used) are formed. Sodium sulphate is soluble and passes off with the wash water, but calcium sulphate remains. The hydrate of the sesquioxide of iron is insoluble in water, and, to all appearances, is unattacked by the cyanide solution ; but the hydrate of protoxide is dissolved with formation of ferrocyanide of potassium.

Mr. C. W. Merrill precipitated ferrous hydrate by caustic potash from a cyanide solution. The solution contained but a small percentage of free cyanide, however, as it had already acted on ore and zinc in the precipitation of the dissolved gold, and it is unlikely that this reaction, regenerating the cyanide of potassium, which had been rendered inert by the solution of the iron, would occur in a comparatively strong solution.

Treatment of Pyritic Ores by Cyanide of Potassium.

—Owing to the rapid decomposition of the pyritic ores when exposed to the atmosphere, precautionary measures have to be taken to treat them effectively. Owing to their successful treatment by the chlorination process, it is at present difficult to say if the cyanide process will eventually prove a serious competitor, as no doubt the process which is the cheapest will maintain itself.

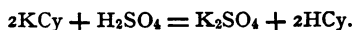
Pyrite (Fe S_2) is decomposed by the oxygen of the air and moisture into soluble ferrous sulphate and free monohydrated sulphuric acid, according to the reaction :



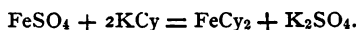
The ferrous sulphate is decomposed by the action of the air to insoluble basic sulphates. In addition, normal ferric sulphate ($\text{Fe}_2 \text{ 3 SO}_4$) is produced, which gradually loses acid

and becomes a soluble basic sulphate, $\text{Fe}_2 \text{O}_3, 2\text{SO}_3$. There are many basic salts of somewhat complex and doubtful composition formed likewise. Thus in an oxidized ore which has contained pyrite are found sulphuric acid, ferrous sulphate, basic ferrous sulphates, ferric sulphate, and basic ferric sulphates, all of which react upon potassium cyanide.

Sulphuric acid reacts upon potassium cyanide with evolution of hydrocyanic acid according to the reaction :



Ferrous sulphate reacts upon cyanide with the formation of ferrous cyanide, a yellowish red flocculent precipitate :



This ferrous cyanide is attacked by the excess of cyanide in the solution, and ferrocyanide of potassium is formed according to the reaction :



That is to say, one molecule of ferrous sulphate decomposes or renders inert six molecules of cyanide of potassium. Other things being equal, if 1 per cent. or 20 lbs. of ferrous cyanide existed in the ore, some 51 lbs. of cyanide would be rendered inert for the solution of gold, and, in fact, would be lost. This, at the average price of chemically pure cyanide, would cost over £5 to £6 per ton of ore treated.

The ferrocyanide of potassium, formed according to the last reaction, is reacted upon, if sufficient acid be present, by an additional quantity of ferrous sulphate, with production of Prussian blue according to the reaction :



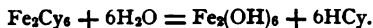
This production of Prussian blue gives a blue colour to the surface of the tailings, or to the solution, and indicates at once that the washing and neutralizing operations have not been carried on properly, and that a great loss of cyanide is taking place.

Ferric salts, when present, unmixed with ferrous salts, de-

compose the cyanide solution with formation of hydrocyanic acid and precipitation of ferric hydrate, according to the reaction :

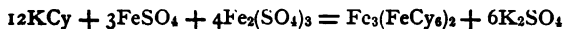


With further decomposition :

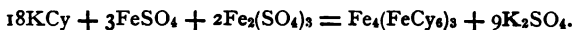


This means that, other things being equal, one molecule of ferric sulphate decomposes six molecules of cyanide. If 1 per cent., or 20 lbs., of ferric sulphate existed in the ore, very nearly the same weight of cyanide, costing £2 to £3, would be destroyed.

If a mixture of ferric and ferrous sulphate, as is probable, exists in partially-oxidized ores, it causes the production, when ferrous sulphate is in excess, of ferrous cyanide, according to the reaction :

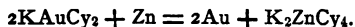


when ferric sulphate is in excess, the production of ferric ferri-cyanide (Prussian blue), according to the reaction :—



These reactions show clearly that washing by water and neutralization by a caustic alkali must be employed to arrive at satisfactory and economical results. It is more than probable that many of the failures already recorded are due to the lack of these precautions. In addition to these reactions, there are many with unknown compounds, the composition of which cannot be expressed, even where the greatest precautions are used, and the operations supervised with the greatest ability and knowledge.

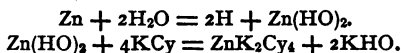
Precipitation of the Gold.—Zinc precipitates the dissolved gold, as the cyanide has more affinity for it than for the gold. Theoretical reaction is :



But much more zinc goes into solution than this reaction calls

for. According to the chemical reaction, the consumption should be 1 oz. of zinc to 6 oz. of gold. The excessive consumption of zinc must be ascribed to other action than the mere replacement of zinc for gold in the double cyanide of gold and potassium.

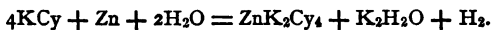
There is comparatively little exact knowledge of the reactions taking place in the zinc precipitation-boxes. One fact is known positively, and that is, that hydrogen is evolved. This does not occur, however, when zinc alone is exposed to a cyanide solution, but after gold is deposited on the zinc, or when zinc is placed in contact with iron. In other words, a galvanic couple is formed, the water is decomposed, and hydrate of zinc is formed, which is attacked by the cyanide forming a double cyanide of zinc and caustic potash. The probable reactions may be expressed as follows :



The production of caustic alkali explains the increased alkalinity of the solution after passing the zinc precipitation-boxes. It may be considered advantageous to a certain extent, however, as carbonic acid, which decomposes the solution, is absorbed by the caustic potash, with formation of a carbonate of the alkalies. Ammonia is formed also, as is indicated by the strong odour of the gas about the boxes.

The precipitate contains, besides the precious metals, many of the base metals, which may be dissolved by the solution. The principal of these are copper, arsenic, and antimony. When a weak cyanide solution contains copper, the copper may be precipitated in preference to the gold, whereas, by increasing the quantity of cyanide, the copper can be kept in solution until the precipitation of the gold is complete.

It is also asserted that, in ordinary cases, the accelerating influence on precipitation of excess of potassic cyanide is probably due to generation of nascent hydrogen.

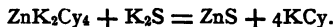


This nascent hydrogen steps into the place of the gold in the auro potassic cyanide :

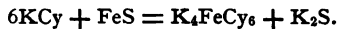


The hydrocyanic acid thus formed recombining with any free alkali present, there is no loss of such cyanogen as was combined with the gold ; from the former of the two equations it would appear that some proportion of the potassic cyanide must be consumed in the zinc boxes. As a matter of fact, there is a consumption in the case of strong cyanide solutions, which, however, in the case of ordinary working (it is claimed *), when solutions are coming off, 0.2 per cent., or so, is quite inappreciable. Indeed, it would appear as if a regeneration of the zinc potassic cyanide took place, the zinc possibly forming a hydrate, and remaining in solution as such, owing to the presence of the free alkali. Given favourable conditions, indeed, the zinc potassic cyanide is itself capable of dissolving gold from ores, and by addition of free alkali to this salt all the cyanogen in it may be determined in the ordinary manner by means of nitrate of silver solution.

Owing to the large amount of zinc which is dissolved in the precipitating-boxes, one would surmise that the working solutions would become in time very highly charged with zinc compounds. Mr. Feldtmann * remarks on this subject, that, as a matter of experience, it may be stated that they do not, to any great extent, and the probable reason for this is, that the small quantities of alkaline sulphides formed serve to precipitate, at least, a portion of the zinc as insoluble sulphide, a regeneration of potassic cyanide taking place simultaneously.



The presence, or rather the formation, of alkaline sulphides in the solutions is explained by the action of potassic cyanide on the iron sulphide contained in partially-decomposed pyritous ores.



* "Notes on Gold Extraction by means of Cyanide of Potassium," by W. R. Feldtmann.

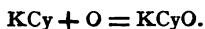
Mr. T. S. MacArthur has even found that, in very exceptional cases, sufficient alkaline sulphide may be formed to be of hindrance to the action of cyanide on the gold, and has discovered a remedy for this in the addition of metallic (particularly lead) salts, capable of forming insoluble sulphides.

Decomposition of the Cyanide.—The compound of cyanogen and potassium is extremely unstable. Not only is it decomposed by mineral acids and acid salts, but by the action at ordinary temperatures of atmospheric carbonic acid, according to the reaction :



Hydrocyanic acid is given off, a portion of which remains in solution and is available for the extraction of gold, but the greater part is dissipated into the air.

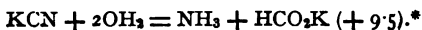
The cyanide is easily oxidized to cyanate :



The cyanate is further oxidized to carbonate according to the reaction :



The nitrogen given off may cause a still further decomposition, for when a current of nitrogen is passed through a cold dilute solution of cyanide of potassium, hydrocyanic acid is evolved without the nitrogen entering into the reaction. This action, when the presence of a chemical causes a reaction between other chemicals in aqueous solution without entering into the reaction itself, is called hydrolysis, and further reaction must be attributed to this property of caustic alkalies, which are, and must be, always present in a working solution of potassium cyanide. If the solution is boiled with acids or alkalies, hydrolysis of the cyanide occurs rapidly, ammonia and formic acid being formed thus :



* According to T. K. Rose, B.Sc., "The Metallurgy of Gold;" London, 1894.

82 THE CHEMISTRY OF THE CYANIDE PROCESS.

If lime is in solution as cyanide of calcium, the following reaction may explain the formation of calcium carbonate :



Hydrogen is always evolved when the gold is precipitated ; without it the foregoing reaction could not be completed. This reaction accounts, moreover, for the formation of ammonia at the zinc boxes. The carbonic acid evolved attacks the cyanide, as mentioned before, thus causing still greater decomposition of the solvent.

It will be seen, therefore, that the decomposition of the cyanide solution, and loss of the solvent energy of the solution for gold, may be divided under the following heads :—

1. Actual decomposition of the solution :

(a) By acids and acid salts present in the ore.

(b) By atmospheric carbonic acid.

(c) By oxidation.

(d) By reaction owing to hydrolysis.

2. The solution of other metals than gold which are not precipitated :—

(a) By metals or their compounds present in the ore, as oxides or carbonates of lead, which are first attacked by the caustic alkali ; by oxides or carbonates of the alkali ; by certain compounds of iron insoluble in water.

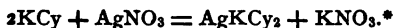
(b) By the replacement of gold in solution by zinc in the precipitation.

(c) By dissolving zinc hydrate, formed by electrolysis, in the precipitation.

It will thus be seen that these losses, under incompetent management, may be frequent, and in many cases may cause unprofitable results.

Testing the Strength of Solutions.—The method employed for estimating the amount of cyanide in a solution is based on the capacity of cyanide of potassium to form a double cyanide with silver—which is added to it in the shape of a titrated solution of nitrate of silver—and on the fact that any

silver solution which is added, beyond the exact quantity which is required, to convert all the potassic cyanide into argentic potassic cyanide, will cause a white precipitate.



As the combining weights of AgNO_3 and K.Cy. are 170 and 65.13 respectively, it follows that 170 parts by weight of argentic nitrate may be added to 2 by 65.13 = 130.26 parts of potassic cyanide before a permanent precipitate ensues. If, therefore, we add from a burette a solution of argentic nitrate containing 17 grms. in a litre, or 1,000 cubic centimetres, to the solution of potassic cyanide to be tested, until a faint precipitate appears, each c.c. of silver solution added will correspond to $\frac{13.02}{1000} = 0.013$ grms. of pure potassic cyanide. From the amount of cyanide solution operated on, the percentage contents can be calculated. It is obvious that the strength of the silver nitrate solution may be so adjusted as to save all calculation.

If, for instance, it is made by dissolving 13.05 grms. of pure silver nitrate in a litre of water, and 10 c.c. of the cyanide solution be taken for a test, then each c.c. of silver solution added will correspond to 0.1 per cent. of pure K.Cy. in the sample tested. In testing very strong solutions—from the dissolving tank, for instance—one-tenth of the quantity of sample may be taken by measuring 10 c.c., diluting with water to 100 c.c., and then drawing off 10 c.c. for test. Of course, in such a case, 1 c.c. of standard silver solution will indicate 1 per cent. of K.Cy. in the original sample of cyanide solution. Addition of a few drops of potassic iodide to the solution to be tested will enhance the accuracy of the test, and will, moreover, annul the danger of our estimating the quantity of cyanide present, consequent on the strong alkalinity of the solution.

In estimating very dilute solutions, such as are employed, for instance, in the Siemens-Halske process, I would recom-

* From Mr. Feldtmann, "Notes on Gold Extraction."

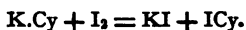
84 THE CHEMISTRY OF THE CYANIDE PROCESS.

mend the employment of a standard decimal silver solution, as the same would ensure greater accuracy.

By taking 100 c.c. of the ordinary standard solution, diluting the same to 1,000 c.c., 1 c.c. of this decimal solution would be equal to 0.01 per cent. of K.Cy. The strength of the standard nitrate solution should be occasionally controlled by a standard cyanide solution.

In making the analysis, the solutions are filtered through a little quicklime. On addition of the silver nitrate a white curdy precipitate forms, which redissolves, and it is added till the solution shows a white precipitate.

An easier and more accurate method is by titration with a standard solution of iodine in potassium iodide until a blue coloration is apparent, a starch solution having been added to the cyanide solution. The reaction is as follows :—



The solution may be checked on chemically pure cyanide, or, better yet, on sodium hyposulphite, and the cubic centimeters equivalent to 1 per cent. of potassium cyanide calculated.

If the percentage of zinc in the solution is required, the solution is evaporated to degrees and the residue treated by any of the well-known methods of analysis for zinc.

The cyanide employed is not chemically pure, and the commercial article contains about 80 to 90 per cent. or over. It is customary in some works to dissolve in a small tank several hundredweight of the cyanide, and test the strength of this *storage solution*, and make up from it the stock solutions. The lumps of cyanide are placed on a filter, made of a coarse sieve covered with jute. A pump is used for causing circulation of the solution.

The insoluble impurities, chiefly carbide of iron, contained in the commercial cyanide remain in the tray. The pumping of the solution into this tray should be kept going fast enough to keep the lumps of cyanide covered by solution, as it is found that alternate exposure of the carbide to the air and immersion in solution of cyanide, causes a certain amount of

decomposition of the latter. A water wash may be applied to remove the last trace of cyanide from the carbide before throwing the latter away. On no account should this carbide be put on the top of the sand in the filter vats, as is sometimes done.* Having determined the strength and quantity of the stock solution, and the strength of the solution in the dissolving tank, the following is a simple formula for arriving at the quantity of the latter requisite to bring the former up to the desired strength :—

A being desired strength of stock solution in per cent. ;

B being present strength of stock solution in per cent. ;

C the strength of dissolving tank solution in per cent. ;

D the quantity in tons, lbs., gals., litres, &c., &c., of stock ;

$\frac{A - B}{C - A} \times D$ = quantity of dissolving tank solution to be added (in tons, lbs., gals., litres, &c., &c.)

For example, supposing the stock solution to consist of 100,000 galls. of 0·4 per cent. strength, and it be desired to bring this up to 0·6 per cent. by adding some 10 per cent. solution, then—

$$\frac{0.6 - 0.4}{10 - 0.6} \times 100,000 = 2127.65 \text{ gals. of the dissolving tank solution.}$$

The following table (pp. 86, 87), which was kindly prepared for me by Mr. Blomfield, chemist of the works, will exemplify the strengths of the different solutions at the various stages while leaching from tailing-vat (this particular lot, which was treated at the Rand Central Ore Reduction works, being somewhat slimey, took a longer time to treat, *i.e.*, about 60 hours) :—

* See Feldtmann on "Gold Extraction."

Time of Leaching.	Original Strength of Solution.	Strength of Solution after Contact.	Remarks.
1st Weak Solution.			} There was considerable moisture in the tailings previous to running on the 1st weak solution.
	0.16 per cent.		
1 hour		0.05 per cent.	
3 hours		0.05 "	
5 "		0.075 "	
7 "		0.1 "	
Strong Solution.			} Draining dry.
	0.35 per cent.		
After 1 hour.		0.1 per cent.	
" 3 hours.		0.2 "	
" 5 "		0.25 "	
" 7 "		0.24 "	
" 9 "		0.26 "	
" 11 "		0.25 "	
" 13 "		0.3 "	
		0.24 "	

Time of Leaching.	Original Strength of Solution.	Strength of Solution after Contact.	Remarks.
1st Weak Wash.			
After 1 hour.	0.16 per cent.	0.26 per cent.	
" 3 hours.		0.3 "	
" 5 "		0.33 "	
2nd Weak Wash.			
1 hour.	0.16 per cent.	0.33 per cent.	
3 hours.		0.3 "	
5 "		0.29 "	
7 "		0.22 "	
3rd Weak Wash.			
1 hour.	0.16 per cent.	0.2 per cent.	
3 hours.		0.17 "	
5 "		0.15 "	
4th Weak Wash.			
1 hour.	0.16 per cent.	0.15 per cent.	
3 hours.		0.14 "	
5 "		0.15 "	
Final Water Wash.			
1 hour.		0.15 per cent.	
3 hours.		0.1 "	
5 "		0.13 "	
7 "		0.05 "	

Determination of Gold in Cyanide Solutions.—

Buchanan's method consists in precipitating a known quantity of solution with excess of argentine nitrate, decomposing the precipitate formed by means of a reducing agent, filtering, drying, and cupelling direct. In detail he found the best method of procedure to be as follows :—195 c.c. of the cyanide solution are transferred to a flask of about 500 c.c. capacity, and mixed with a few drops of potassic chromate. Argentic nitrate solution of any convenient strength, say, 5 per cent., is then added until the characteristic reddish tinge of the chromate shows that the reaction is complete. Then take 10 to 20 grms. of zinc dust or shavings, mix them thoroughly with the precipitate and solution in the flask, and add 2 or 3 c.c. of 10 per cent. sulphuric acid. Allow to stand for 10 minutes, add excess of sulphuric acid to dissolve the remainder of the zinc, filter, wash once, dry, and incinerate on a roasting dish in the muffle and cupel with a little lead. This method does away with the trouble of fluxing, and has the advantage of allowing of a great number of samples being done together. The results on the whole are slightly lower than those obtained by the ordinary precipitation method.

Crosse's method consists in taking $\frac{1}{2}$ or 1 litre of cyanide solution, containing gold, and adding excess of nitrate of silver. A precipitate of cyanide of silver is formed, and also argento-auro-cyanide, which is insoluble. This precipitate quickly settles, and is filtered on to a large filter. It is then put in a crucible covered with flux and, say, 500 grs. of litharge. In 10 minutes the fusion is complete, the button of lead obtained is cupelled, and the gold parted from the silver. This method allows of a larger quantity of liquid to be operated upon, is easily carried out, and does not require much watching. In the case of strong cyanide solutions most of the potassic cyanide is decomposed by addition of acid previous to adding the silver nitrate, to avoid the otherwise heavy consumption of the latter.

Extraction Tests.—Mr. Feldtmann gives the following

instructions as to the best tests for determining if an ore is amenable to cyanide treatment.

It is assumed that the total sample is crushed fine enough to pass a 30-mesh sieve.

1. Assay a portion of the sample.

2. Determine the amount of cyanide it will consume by shaking test. For example: 200 grms. of ore are placed in a glass stoppered bottle with a 100 c.c. of solution of cyanide of 0.5 per cent. strength, and shaken for twenty minutes or so.

A portion of the solution is then filtered off and tested. Supposing it to be reduced in strength to 0.4 per cent., showing a consumption of 0.1 per cent. on the solution, or half as much, *i.e.*, 0.05 per cent. on the ore (or 1 lb. per ton), we might safely conclude that the ore will not require any preliminary treatment before leaching with cyanide. The largest consumption of cyanide takes place almost immediately after the solution comes in contact with the ore, and after twenty minutes' shaking it is generally safe to assume that there will not be much further consumption.

3. If it is found that the consumption of cyanide is excessive, a third portion of the ore is tested for "cyanicide," by which is meant free acid, soluble and basic iron salts, and indeed any cyanide destroying substance which may be counteracted by alkali. A solution of caustic soda of known strength is run, little by little, from a burette into a weighed quantity of the ore mixed with water, the mixture being well stirred after each addition of alkali, until a drop, taken out on a glass rod, will just turn red litmus slightly blue. A convenient quantity of ore to operate on is 200 grms., and, using an alkali solution of 10 grms. commercial caustic soda to the litre of water, each cubic centimetre will correspond to $\frac{1}{10}$ th lb. of the same quality caustic soda required to the ton (of 2,000) of ore. If the consumption of soda be more than 3 lbs. per ton, it will generally be found advisable to water wash the ore before giving alkaline treatment. It is easy to determine the amount of alkali which may be saved through a preliminary water wash, by first estimating total "cyanicide,"

then taking another sample, water washing first, and estimating remaining "cyanide."

It is usual, when reporting the amount of "cyanide" in an ore, to do so in terms of pounds and fractions of caustic soda required to neutralize a ton of the ore.

Should the consumption of cyanide in No. 2 test have proved larger than the amount of iron salts and acid present would account for, there is probably copper in the ore. The cyanide solution from test No. 2 may be conveniently examined for copper by evaporating with nitric acid, taking up with a little more nitric acid, diluting and precipitating with ammonia, when copper will be indicated by the characteristic blue colouration of the liquid.

4. Several samples of ore are weighed out for extraction tests. A suitable vessel for testing extraction is a lamp glass, fitted with an india-rubber stopper, with a glass tube through it, which may be closed by means of a small piece of rubber tubing and burette clip. A filter is formed over the rubber stopper by means of a piece of sponge, some filter-paper, or some asbestos fibre.

Into such vessels the samples are placed—say, 200 grms. each—and they must then receive whatever preliminary treatment test No. 3 has shown to be needful in the way of water and alkali washes, 100 c.c. of a 0.5 per cent. solution of cyanide is then poured on. The various samples may be allowed to stand for different periods, say, one, two, and three days respectively, or more, if thought fit; the cyanide solutions being then drawn off and tested, and the ore, after water washing to remove all dissolved gold, being assayed again.

INDEX.

A CID ores and tailings, 32
Alkaline solution, 24

Anodes, 43

Argall, Mr. Philip, on precipitation, 27

B ALL Mill Grusonworks, 62
Bettel, Mr. W., 6, 13, 27, 36

Black Reef, 36

Blomfield, Mr., of Rand Central Ore Reduction Company, 28, 85

Bottom of vats, 14

Butters, Mr. Charles, 12
patent discharge lid, 19

Butters & Mein's distributor, 7

C AUSTIC lime, 33
Caustic wash, 24

Charging and discharging, 12

Clean-up, 27

Concentrates, treatment of, 33

Concentration, 33

Cost of plant, 39
of treatment, 38

Crown Reef mine, 5
works, 57

Cyanide, consumption of, 39
decomposition of, 81
plant, erection of, 1
process, chemistry of, 69
synopsis of, 23
solutions, 24, 25
known in middle ages, vii
treatment, adverse conditions affecting, 36

D ETERMINATION of gold in
solutions, 87

Buchanan's method, 87

Crosse's method, 87

Direct filling, advantages and disadvantages of, 13

Discharge lid, Butters' patent, 19
Lauder's, grade of, 3

Discharging tailings, 18

Distributor, Butters & Mein's, 7
sizes of, 12

Dry crushing, 67

ELECTRIC precipitation, advantages of, 44
Extraction tests, 87

FELDTMANN, Mr., on "Gold Extraction," 18, 26, 31, 80, 83
Filter-vats or leaching tanks, 14
 number required, 7
 construction of, 15
Fluxing of gold slimes, 31
Fraser and Chalmers, Messrs., 2
Frue vanners, 34

GERMAN Government, report to, ix
Gold slimes, 29

HYDRAULIC separators, 13

INTERMEDIATE filling, 7
 advantages of, 12

JANIN, Mr. Louis, experiments on silver ores, 73
Jennings, Mr. H., 4

LANGLAAGTE Block B, 34
 Estate and Gold Mining Company, 7, 34, 66
Lydenburg cupriferous ores, 26
Leaching tanks, 14

MACARTHUR-FORREST Company, public indebtedness to, ix

Mechanical haulage, 2
Meyer and Charlton Gold Mining Company, 11
Mercury and electric deposition, 41
Metal cathodes, 42
Metallurgy, methods of, v
Muffle roasting furnace, 30

OSWELL, Mr., of Worcester works, 46

PAN amalgamation, x
 Paarl Central Works, 5
Pioneer Gold Mining Company, 11
Plan of works for cyanide plant, 1
Plant, cost of, 39
Precipitate, roasting the, 30
Precipitation of gold, 25, 78
 conditions influencing, 27
 boxes, construction of, 21
Princess works, 3
Pumps, 19
Pyritic ore, treatment of, 75

RADEMACHER, Mr., of Humboldt works, 34
Rand Central works, 32, 66
Results of experiments, 75
 of processes, 37, 46
Roasting the precipitate, 30
Robinson mine, 35, 39
Rothschild, Messrs., report to, ix

SCHMEISSER, Bergrath, report by, x

Siemens and Halske process, 50
Simmer and Jack works, 61
 yield of concentrates, xi
Smart and Torrente, Messrs., 61
Slimes, elimination of, 3
 smelting of, 31
Smith, Mr. Hamilton, report by, ix
Solubility of metals and minerals
 other than gold, 72
Solution drainage pipes, 17
 of the gold, 69
Solutions, testing strength of, 82
Solvents for gold, vii
Stock solution tanks, 19
Stamping, effect of, on ores, 5

TAILING dams and reservoirs, 2
 pumps, 3
 wheels, 3
Tailings, time for treatment of, 27

Torrente and Smart, Messrs., 61
Treatment, cost of, 38

VATS required, number of, 7
 calculating contents of, 20
 methods of filling, 7, 13

WATER wash, 25
 Williams, Mr., of Crown
 Reef mine, 5, 34
Witwatersrand, production of gold
 in, ix, 4
Worcester Gold Mining Company,
 II
 works, working scheme at, 50

ZINC precipitation boxes, 20
 shavings, 26

BOOKS FOR MINERS AND METALLURGISTS.

[NOTE.—For List of Works by Mr. M. EISSLER on the METALLURGY OF GOLD and other METALS, see page facing title of this Work.]

Machinery for Metalliferous Mines: A Practical Treatise for Mining Engineers, Metallurgists and Managers of Mines. By E. HENRY DAVIES, M.E., F.G.S. Crown 8vo, 580 pp., with upwards of 300 Illustrations. 12s. 6d. cloth.

"Mr. Davies, in this handsome volume, has done the advanced student and the manager of mines good service. Almost every kind of machinery in actual use is carefully described, and the woodcuts and plates are good."—*Athenaeum*.

The Prospector's Handbook: A Guide for the Prospector and Traveller in Search of Metal-Bearing or other Valuable Minerals. By J. W. ANDERSON, M.A. (Camb.). F.R.G.S., Author of "Fiji and New Caledonia." Sixth Edition, thoroughly Revised and Enlarged. Small crown 8vo, 3s. 6d. cloth.

"The author has managed to pack as much practical detail into his pages as would supply material for a book three times its size."—*Mining Journal*.

Notes and Formulæ for Mining Students. By JOHN HERMAN MERIVALE, M.A., Certificated Colliery Manager, Professor of Mining in the Durham College of Science, Newcastle-upon-Tyne. Third Edition, Revised and Enlarged. Small crown 8vo, 2s. 6d. cloth.

"Invaluable to any one who is working up for an examination on mining subjects."—*Coal and Iron Trades' Review*.

The Miner's Handbook: A Handy Book of Reference on the Subjects of Mineral Deposits, Mining Operations, Ore Dressing, &c. For the Use of Students and others interested in Mining matters. Compiled by JOHN MILNE, F.R.S., Professor of Mining in the Imperial University of Japan. Square 18mo, 7s. 6d. cloth.

"Professor Milne's handbook is sure to be received with favour by all connected with mining, and will be extremely popular among students."—*Athenaeum*.

A Pocket-Book for Miners and Metallurgists. Comprising Rules, Formulæ, Tables, and Notes, for Use in Field and Office Work. By F. DANVERS POWER, F.G.S., M.E. Fcap. 8vo, 9s. leather, gilt edges.

"This excellent book is an admirable example of its kind, and ought to find a large sale amongst English-speaking prospectors and mining engineers."—*Engineering*.

A Treatise on Metalliferous Minerals and Mining. By D. C. DAVIES, F.G.S. Fifth Edition, thoroughly Revised and much Enlarged, by his Son, E. HENRY DAVIES, M.E., F.G.S. With about 150 Illustrations. Crown 8vo, 12s. 6d. cloth.

"Neither the practical miner nor the general reader, interested in mines, can have a better book for his companion and his guide."—*Mining Journal*.

British Mining: A Treatise on the History, Discovery, Practical Development, and Future Prospects of Metalliferous Mines in the United Kingdom. By ROBERT HUNT, F.R.S., Keeper of Mining Records; Editor of "Ure's Dictionary of Arts, Manufactures, and Mines," &c. Upwards of 950 pp., with 230 Illustrations. Second Edition, Revised. Super-royal 8vo, £2 2s. cloth.

"One of the most valuable works of reference of modern times. . . . The language and style adopted are good, and the treatment of the various subjects laborious, conscientious, and scientific."—*Engineering*.

*• Full Catalogues free by post on application.

LONDON: CROSBY LOCKWOOD & SON, 7, Stationers' Hall Court.

7, STATIONERS' HALL COURT, LONDON, E.C.
August, 1894.

A
CATALOGUE OF BOOKS

INCLUDING NEW AND STANDARD WORKS IN
ENGINEERING: CIVIL, MECHANICAL, AND MARINE;
ELECTRICITY AND ELECTRICAL ENGINEERING;
MINING, METALLURGY; ARCHITECTURE,
BUILDING, INDUSTRIAL AND DECORATIVE ARTS;
SCIENCE, TRADE AND MANUFACTURES;
AGRICULTURE, FARMING, GARDENING;
AUCTIONEERING, VALUING AND ESTATE AGENCY;
LAW AND MISCELLANEOUS.

PUBLISHED BY

CROSBY LOCKWOOD & SON.

MECHANICAL ENGINEERING, etc.

D. K. Clark's Pocket-Book for Mechanical Engineers.

THE MECHANICAL ENGINEER'S POCKET-BOOK OF TABLES, FORMULÆ, RULES AND DATA. A Handy Book of Reference for Daily Use in Engineering Practice. By D. KINNAR CLARK, M.Inst.C.E., Author of "Railway Machinery," "Tramways," &c. Second Edition, Revised and Enlarged. Small 8vo, 700 pages, 9s. bound in flexible leather covers, with rounded corners and gilt edges.

SUMMARY OF CONTENTS.

MATHEMATICAL TABLES.—MEASUREMENT OF SURFACES AND SOLIDS.—ENGLISH WEIGHTS AND MEASURES.—FRENCH METRIC WEIGHTS AND MEASURES.—FOREIGN WEIGHTS AND MEASURES.—MONEYS.—SPECIFIC GRAVITY WEIGHT AND VOLUME.—MANUFACTURED METALS.—STEEL PIPES.—BOLTS AND NUTS.—SUNDRY ARTICLES IN WROUGHT AND CAST IRON, COPPER, BRASS, LEAD, TIN, ZINC.—STRENGTH OF MATERIALS.—STRENGTH OF TIMBER.—STRENGTH OF CAST IRON.—STRENGTH OF WROUGHT IRON.—STRENGTH OF STEEL.—TENSILE STRENGTH OF COPPER, LEAD, ETC.—RESISTANCE OF STONES AND OTHER BUILDING MATERIALS.—RIVETED JOINTS IN BOILER PLATES.—BOILER SHELLS.—WIRE ROPES AND HEMP ROPES.—CHAINS AND CHAIN CABLES.—FRAMING.—HARDNESS OF METALS, ALLOYS AND STONES.—LABOUR OF ANIMALS.—MECHANICAL PRINCIPLES.—GRAVITY AND FALL OF BODIES.—ACCELERATING AND RETARDING FORCES.—MILL GEARING, SHAFTING, ETC.—TRANSMISSION OF MOTIVE POWER.—HEAT.—COMBUSTION: FUELS.—WARMING, VENTILATION, COOKING STOVES.—STEAM.—STEAM ENGINES AND BOILERS.—RAILWAYS.—TRAMWAYS.—STEAM SHIPS.—PUMPING STEAM ENGINES AND PUMPS.—COAL GAS, GAS ENGINES, ETC.—AIR IN MOTION.—COMPRESSED AIR.—HOT AIR ENGINES.—WATER POWER.—SPEED OF CUTTING TOOLS.—COLOURS.—ELECTRICAL ENGINEERING.

* * * OPINIONS OF THE PRESS.

Mr. Clark manifests what is an innate perception of what is likely to be useful in a pocket-book, and he is really unrivalled in the art of condensation. Very frequently we find the information on a given subject is supplied by giving a summary description of an experiment, and a statement of the results obtained. There is a very excellent steam table, occupying five and a-half pages; and there are rules given for several calculations, which rules cannot be found in other pocket-books, as, for example, that on page 497, for getting at the quantity of water in the shape of priming in any known weight of steam. It is very difficult to hit upon any mechanical engineering subject concerning which this work supplies no information, and the excellent index at the end adds to its utility. In one word, it is an exceedingly handy and efficient tool, possessed of which the engineer will be saved many a wearisome calculation, or yet more wearisome hunt through various text-books and treatises, and, as such, we can heartily recommend it to our readers, who must not run away with the idea that Mr. Clark's Pocket-book is only Molesworth in another form. On the contrary, each contains what is not to be found in the other; and Mr. Clark takes more room and deals at more length with many subjects than Molesworth possibly could.

The Engineer.

It would be found difficult to compress more matter within a similar compass, or produce a book of 650 pages which should be more compact or convenient for pocket reference. . . . Will be appreciated by mechanical engineers of all classes."—*Practical Engineer.*

"Just the kind of work that practical men require to have near to them."—*English Mechanic*

MR. HUTTON'S PRACTICAL HANDBOOKS.

Handbook for Works' Managers.

THE WORKS' MANAGER'S HANDBOOK OF MODERN RULES, TABLES, AND DATA. For Engineers, Millwrights, and Boiler Makers; Tool Makers, Machinists, and Metal Workers; Iron and Brass Founders, &c. By W. S. HUTTON, Civil and Mechanical Engineer, Author of "The Practical Engineer's Handbook." Fourth Edition, carefully Revised and partly Re-written. In One handsome Volume, medium 8vo, price 12s. strongly bound.

"The Author having compiled Rules and Data for his own use in a great variety of modern engineering work, and having found his notes extremely useful, decided to publish them—revised to date—believing that a practical work, suited to the DAILY REQUIREMENTS of MODERN ENGINEERS, would be favourably received."

In the Fourth Edition the First Section has been re-written and improved by the addition of numerous illustrations and new matter relating to STEAM ENGINES and GAS ENGINES. The Second Section has been enlarged and Illustrated, and throughout the book a great number of emendations and alterations have been made, with the object of rendering the book more generally useful.

* OPINIONS OF THE PRESS.

"The author treats every subject from the point of view of one who has collected workshop notes for application in workshop practice, rather than from the theoretical or literary aspect. The volume contains a great deal of that kind of information which is gained only by practical experience, and is seldom written in books."—*Engineer*.

"The volume is an exceedingly useful one, brimful with engineers' notes, memoranda, and rules, and well worthy of being on every mechanical engineer's bookshelf."—*Mechanical World*.

"The information is precisely that likely to be required in practice. . . . The work forms a desirable addition to the library not only of the works' manager, but of anyone connected with general engineering."—*Mining Journal*.

"A formidable mass of facts and figures, readily accessible through an elaborate index of 'works' connected with the metal trades."—*Ryland's Iron Trades Circular*.

"Brimful of useful information, stated in a concise form, Mr. Hutton's books have met a pressing want among engineers. The book must prove extremely useful to every practical man possessing a copy."—*Practical Engineer*.

New Manual for Practical Engineers.

THE PRACTICAL ENGINEER'S HAND-BOOK. Comprising a Treatise on Modern Engines and Boilers: Marine, Locomotive and Stationary. And containing a large collection of Rules and Practical Data relating to recent Practice in Designing and Constructing all kinds of Engines, Boilers, and other Engineering work. The whole constituting a comprehensive Key to the Board of Trade and other Examinations for Certificates of Competency in Modern Mechanical Engineering. By WALTER S. HUTTON, Civil and Mechanical Engineer, Author of "The Works' Manager's Handbook for Engineers," &c. With upwards of 370 Illustrations. Fourth Edition, Revised, with Additions. Medium 8vo, nearly 500 pp., price 18s. Strongly bound.

"This work is designed as a companion to the Author's 'WORKS' MANAGER'S HAND-BOOK.' It possesses many new and original features, and contains, like its predecessor, a quantity of matter not originally intended for publication, but collected by the author for his own use in the construction of a great variety of MODERN ENGINEERING WORK."

The information is given in a condensed and concise form, and is illustrated by upwards of 370 Woodcuts; and comprises a quantity of tabulated matter of great value to all engaged in designing, constructing, or estimating for ENGINES, BOILERS, and OTHER ENGINEERING WORK.

* OPINIONS OF THE PRESS.

"We have kept it at hand for several weeks, referring to it as occasion arose, and we have not on a single occasion consulted its pages without finding the information of which we were in quest."—*Athenaeum*.

"A thoroughly good practical handbook, which no engineer can go through without learning something that will be of service to him."—*Marine Engineer*.

"An excellent book of reference for engineers, and a valuable text-book for students of engineering."—*Scientist*.

"This valuable manual embodies the results and experience of the leading authorities on mechanical engineering."—*Building News*.

"The author has collected together a surprising quantity of rules and practical data, and has shown much judgment in the selections he has made. . . . There is no doubt that this book is one of the most useful of its kind published, and will be a very popular compendium."—*Engineer*.

"A mass of information, set down in simple language, and in such a form that it can be easily referred to at any time. The matter is uniformly good and well chosen, and is greatly elucidated by the illustrations. The book will find its way on to most engineers' shelves, where it will rank as one of the most useful books of reference."—*Practical Engineer*.

"Full of useful information and should be found on the office shelf of all practical engineers."—*English Mechanic*.

MR. HUTTON'S PRACTICAL HANDBOOKS—continued.**Practical Treatise on Modern Steam-Boilers.**

STEAM-BOILER CONSTRUCTION. A Practical Handbook for Engineers, Boiler-Makers, and Steam Users. Containing a large Collection of Rules and Data relating to Recent Practice in the Design, Construction, and Working of all Kinds of Stationary, Locomotive, and Marine Steam-Boilers. By **WALTER S. HUTTON**, Civil and Mechanical Engineer, Author of "The Works' Manager's Handbook," "The Practical Engineer's Handbook," &c. With upwards of 300 Illustrations. Second Edition. Medium 8vo, 18s. cloth.

✎ This work is issued in continuation of the Series of Handbooks written by the Author, viz:—"THE WORKS' MANAGER'S HANDBOOK" and "THE PRACTICAL ENGINEER'S HANDBOOK," which are so highly appreciated by Engineers for the practical nature of their information; and is consequently written in the same style as those works.

The Author believes that the concentration, in a convenient form for easy reference, of such a large amount of thoroughly practical information on Steam-Boilers, will be of considerable service to those for whom it is intended, and he trusts the book may be deemed worthy of as favourable a reception as has been accorded to its predecessors.

***.* OPINIONS OF THE PRESS.**

"Every detail, both in boiler design and management, is clearly laid before the reader. The volume shows that boiler construction has been reduced to the condition of one of the most exact sciences; and such a book is of the utmost value to the *An de siècle* Engineer and Works' Manager."—*Marine Engineer*.

"There has long been room for a modern handbook on steam boilers; there is not that room now, because Mr. Hutton has filled it. It is a thoroughly practical book for those who are occupied in the construction, design, selection, or use of boilers."—*Engineer*.

"The book is of so important and comprehensive a character that it must find its way into the libraries of everyone interested in boiler using or boiler manufacture if they wish to be thoroughly informed. We strongly recommend the book for the intrinsic value of its contents."—*Machinery Market*.

"The value of this book can hardly be over-estimated. The author's rules, formulae, &c., are all very fresh, and it is impossible to turn to the work and not find what you want. No practical engineer should be without it."—*Colliery Guardian*.

Hutton's "Modernised Templeton."

THE PRACTICAL MECHANICS' WORKSHOP COMPANION. Comprising a great variety of the most useful Rules and Formulae in Mechanical Science, with numerous Tables of Practical Data and Calculated Results for Facilitating Mechanical Operations. By **WILLIAM TEMPLETON**, Author of "The Engineer's Practical Assistant," &c. &c. Sixteenth Edition, Revised, Modernised, and considerably Enlarged by **WALTER S. HUTTON**, C.E., Author of "The Works' Manager's Handbook," "The Practical Engineer's Handbook," &c. Fcap. 8vo, nearly 500 pp., with 8 Plates and upwards of 250 Illustrative Diagrams, 6s., strongly bound for workshop or pocket wear and tear.

***.* OPINIONS OF THE PRESS.**

"In its modernised form Hutton's 'Templeton' should have a wide sale, for it contains much valuable information which the mechanic will often find of use, and not a few tables and notes which he might look for in vain in other works. This modernised edition will be appreciated by all who have learned to value the original editions of 'Templeton.'"—*English Mechanic*.

"It has met with great success in the engineering workshop, as we can testify; and there are a great many men who, in a great measure, owe their rise in life to this little book."—*Building News*.

"This familiar text-book—well known to all mechanics and engineers—is of essential service to the every-day requirements of engineers, millwrights, and the various trades connected with engineering and building. The new modernised edition is worth its weight in gold."—*Building News*. (Second Notice.)

"This well-known and largely-used book contains information, brought up to date, of the sort so useful to the foreman and draughtsman. So much fresh information has been introduced as to constitute it practically a new book. It will be largely used in the office and workshop."—*Mechanical World*.

"The publishers wisely entrusted the task of revision of this popular, valuable, and useful book to Mr. Hutton, than whom a more competent man they could not have found."—*Iron*.

Templeton's Engineer's and Machinist's Assistant.

THE ENGINEER'S, MILLWRIGHT'S, and MACHINIST'S PRACTICAL ASSISTANT. A collection of Useful Tables, Rules and Data. By **WILLIAM TEMPLETON**. 7th Edition, with Additions. 18mo, 2s. 6d. cloth.

***.* OPINIONS OF THE PRESS.**

"Occupies a foremost place among books of this kind. A more suitable present to an apprentice to any of the mechanical trades could not possibly be made."—*Building News*.

"A deservedly popular work. It should be in the 'drawer' of every mechanic."—*English Mechanic*.

Foley's Office Reference Book for Mechanical Engineers.

THE MECHANICAL ENGINEER'S REFERENCE BOOK, for Machine and Boiler Construction. In Two Parts. Part I. GENERAL ENGINEERING DATA. Part II. BOILER CONSTRUCTION. With 51 Plates and numerous Illustrations. By NELSON FOLEY, M.I.N.A. Folio, £5 5s. half-bound.

SUMMARY OF CONTENTS.

PART I.

MEASURES.—CIRCUMFERENCES AND AREAS, &c., SQUARES, CUBES, FOURTH POWERS.—SQUARE AND CUBE ROOTS.—SURFACE OF TUBES—RECIPROCALLS.—LOGARITHMS.—MENSURATION.—SPECIFIC GRAVITIES AND WEIGHTS.—WORK AND POWER.—HEAT.—COMBUSTION.—EXPANSION AND CONTRACTION.—EXPANSION OF GASES.—STEAM.—STATIC FORCES.—GRAVITATION AND ATTRACTION.—MOTION AND COMPUTATION OF RESULTING FORCES.—ACCUMULATED WORK.—CENTRE AND RADIUS

WITH DIAGRAMS FOR VALVE-GEAR, BELTING AND ROPES, DISCHARGE AND SUCTION PIPES, SCREW PROPELLERS, AND COPPER PIPES.

OF GYRATION.—MOMENT OF INERTIA.—CENTRE OF OSCILLATION.—ELECTRICITY.—STRENGTH OF MATERIALS.—ELASTICITY.—TEST SHEETS OF METALS.—FRICTION.—TRANSMISSION OF POWER.—FLOW OF LIQUIDS.—FLOW OF GASES.—AIR PUMPS, SURFACE CONDENSERS, &c.—SPEED OF STEAMSHIPS.—PROPELLERS.—CUTTING TOOLS.—FLANGES.—COPPER SHEETS AND TUBES.—SCREWS, NUTS, BOLT HEADS, &c.—VARIOUS RECIPES AND MISCELLANEOUS MATTER.

PART II.

TREATING OF, POWER OF BOILERS.—USEFUL RATIOS.—NOTES ON CONSTRUCTION.—CYLINDRICAL BOILER SHELLS.—CIRCULAR FURNACES.—FLAT PLATES.—STAYS.—GIRDERS.—SCREWS.—HYDRAULIC TESTS.—

WITH DIAGRAMS FOR ALL BOILER CALCULATIONS AND DRAWINGS OF MANY VARIETIES OF BOILERS.

RIVETING.—BOILER SETTING, CHIMNEYS, AND MOUNTINGS.—FUELS, &c.—EXAMPLES OF BOILERS AND SPEEDS OF STEAMSHIPS.—NOMINAL AND NORMAL HORSE POWER.

. OPINIONS OF THE PRESS.

"This appears to be a work for which there should be a large demand on the part of mechanical engineers. It is no easy matter to compile a book of this class, and the labour involved is enormous, particularly when—as the author informs us—the majority of the tables and diagrams have been specially prepared for the work. The diagrams are exceptionally well executed, and generally constructed on the method adopted in a previous work by the same author. . . . The tables are very numerous, and deal with a greater variety of subjects than will generally be found in a work of this kind; they have evidently been compiled with great care and are unusually complete. All the information given appears to be well up to date. . . . It would be quite impossible within the limits at our disposal to even enumerate all the subjects treated; it should, however, be mentioned that the author does not confine himself to a mere bald statement of formulae and laws, but in very many instances shows succinctly how these are derived. . . . The latter part of the book is devoted to diagrams relating to Boiler Construction, and to nineteen beautifully-executed plates of working drawings of boilers and their details. As samples of how such drawings should be got out, they may be cordially recommended to the attention of all young, and even some elderly, engineers. . . . Altogether the book is one which every mechanical engineer may, with advantage to himself add to his library."—*Industries*.

"Mr. Foley is well fitted to compile such a work. . . . The diagrams are a great feature of the work. . . . Regarding the whole work it may be very fairly stated that Mr. Foley has produced a volume which will undoubtedly fulfil the desire of the author and become indispensable to all mechanical engineers."—*Marine Engineer*.

"We have carefully examined this work, and pronounce it a most excellent reference book for the use of marine engineers."—*Journal of American Society of Naval Engineers*.

"A veritable monument of industry on the part of Mr. Foley, who has succeeded in producing what is simply invaluable to the engineering profession."—*Steamships*.

Coal and Speed Tables.

A POCKET BOOK OF COAL AND SPEED TABLES, for Engineers and Steam-users. By NELSON FOLEY, Author of "The Mechanical Engineer's Reference Book." Pocket-size, 3s. 6d. cloth.

"These tables are designed to meet the requirements of every-day use; they are of sufficient scope for most practical purposes, and may be commended to engineers and users of steam."—*Iron*.

"This pocket-book well merits the attention of the practical engineer. Mr. Foley has compiled a very useful set of tables, the information contained in which is frequently required by engineers, coal consumers and users of steam."—*Iron and Coal Trades Review*.

Steam Engine.

TEXT-BOOK ON THE STEAM ENGINE. With a Supplement on Gas Engines, and PART II. ON HEAT ENGINES. By T. M. GOODEVE, M.A., Barrister-at-Law, Professor of Mechanics at the Royal College of Science, London; Author of "The Principles of Mechanics," "The Elements of Mechanism," &c. Twelfth Edition, Enlarged. With numerous Illustrations. Crown 8vo, 6s. cloth.

"Professor Goodeve has given us a treatise on the steam engine which will bear comparison with anything written by Huxley or Maxwell, and we can award it no higher praise."—*Engineer*.

"Mr. Goodeve's text-book is a work of which every young engineer should possess himself."—*Mining Journal*.

Gas Engines.

ON GAS-ENGINES. With Appendix describing a Recent Engine with Tube Igniter. By T. M. GOODEVE, M.A. Crown 8vo, 2s. 6d. cloth.

"Like all Mr. Goodeve's writings, the present is no exception in point of general excellence. It is a valuable little volume."—*Mechanical World*.

Steam Engine Design.

A HANDBOOK ON THE STEAM ENGINE, with especial Reference to Small and Medium-sized Engines. For the Use of Engine-Makers, Mechanical Draughtsmen, Engineering Students and Users of Steam Power. By HERMAN HAEDER, C.E. English Edition, Re-edited by the Author from the Second German Edition, and Translated, with considerable Additions and Alterations, by H. H. P. POWLES, A.M.I.C.E., M.I.M.E. With nearly 1,100 Illustrations. Crown 8vo, 9s. cloth.

"A perfect encyclopædia of the steam engine and its details, and one which must take a permanent place in English drawing-offices and workshops."—*A Foreman Pattern-maker*.

"This is an excellent book, and should be in the hands of all who are interested in the construction and design of medium sized stationary engines. . . . A careful study of its contents and the arrangement of the sections leads to the conclusion that there is probably no other book like it in this country. The volume aims at showing the results of practical experience, and it certainly may claim a complete achievement of this idea."—*Nature*.

"There can be no question as to its value. We cordially commend it to all concerned in the design and construction of the steam engine."—*Mechanical World*.

Steam Boilers.

A TREATISE ON STEAM BOILERS: Their Strength, Construction, and Economical Working. By ROBERT WILSON, C.E. Fifth Edition. 12mo, 6s. cloth.

"The best treatise that has ever been published on steam boilers."—*Engineer*.

"The author shows himself perfect master of his subject, and we heartily recommend all employing steam power to possess themselves of the work."—*Ryland's Iron Trade Circular*.

Boiler Chimneys.

BOILER AND FACTORY CHIMNEYS: Their Draught-Power and Stability. With a Chapter on Lightning Conductors. By ROBERT WILSON, A.I.C.E., Author of "A Treatise on Steam Boilers," &c. Second Edition. Crown 8vo, 3s. 6d. cloth.

"A valuable contribution to the literature of scientific building."—*The Builder*.

Boiler Making.

THE BOILER-MAKER'S READY RECKONER & ASSISTANT. With Examples of Practical Geometry and Templatting, for the Use of Platers, Smiths and Riveters. By JOHN COURTNEY, Edited by D. K. CLARK, M.I.C.E. Third Edition, 480 pp., with 140 Illusts. Fcap. 8vo, 7s. half-bound.

"No workman or apprentice should be without this book."—*Iron Trade Circular*.

Locomotive Engine Development.

THE LOCOMOTIVE ENGINE AND ITS DEVELOPMENT. A Popular Treatise on the Gradual Improvements made in Railway Engines between 1803 and 1893. By CLEMENT E. STRETTON, C.E., Author of "Safe Railway Working," &c. Second Edition, Revised and much Enlarged. With 95 Illustrations. Crown 8vo, 3s. 6d. cloth. [Just published.]

"Students of railway history and all who are interested in the evolution of the modern locomotive will find much to attract and entertain in this volume."—*The Times*.

"The author of this work is well known to the railway world, and no one probably has a better knowledge of the history and development of the locomotive. The volume before us should be of value to all connected with the railway system of this country."—*Nature*.

Fire Engineering.

FIRES, FIRE-ENGINES, AND FIRE-BRIGADES. With a History of Fire-Engines, their Construction, Use, and Management; Remarks on Fire-Proof Buildings, and the Preservation of Life from Fire; Statistics of the Fire Appliances in English Towns; Foreign Fire Systems; Hints on Fire Brigades, &c. &c. By CHARLES F. T. YOUNG, C.E. With numerous Illustrations. 544 pp., demy 8vo, £1 4s. cloth.

"To those interested in the subject of fires and fire apparatus, we most heartily commend this book. It is the only English work we now have upon the subject."—*Engineering*.

"It displays much evidence of careful research; and Mr. Young has put his facts neatly together. His acquaintance with the practical details of the construction of steam fire engines, old and new, and the conditions with which it is necessary they should comply, is accurate and full."—*Engineer*.

Estimating for Engineering Work, &c.

ENGINEERING ESTIMATES, COSTS AND ACCOUNTS: A Guide to Commercial Engineering. With numerous Examples of Estimates and Costs of Millwright Work, Miscellaneous Productions, Steam Engines and Steam Boilers; and a Section on the Preparation of Costs Accounts. By A GENERAL MANAGER. Demy 8vo, 12s. cloth.

"This is an excellent and very useful book, covering subject-matter in constant requisition in every factory and workshop. . . . The book is invaluable, not only to the young engineer, but also to the estimate department of every works."—*Builder*.

"We accord the work unqualified praise. The information is given in a plain, straightforward manner, and bears throughout evidence of the intimate practical acquaintance of the author with every phase of commercial engineering."—*Mechanical World*.

Engineering Construction.

PATTERN-MAKING: A Practical Treatise, embracing the Main Types of Engineering Construction, and including Gearing, both Hand and Machine made, Engine Work, Sheaves and Pulleys, Pipes and Columns, Screws, Machine Parts, Pumps and Cocks, the Moulding of Patterns in Loam and Greensand, &c., together with the methods of Estimating the weight of Castings, to which is added an Appendix of Tables for Workshop Reference. By A FOREMAN PATTERN MAKER. Second Edition, thoroughly Revised and much Enlarged. With upwards of 450 Illustrations. Crown 8vo, 7s. 6d. cloth. [Just published.]

"A well-written technical guide, evidently written by a man who understands and has practised what he has written about. . . . We cordially recommend it to engineering students, young journeymen, and others desirous of being initiated into the mysteries of pattern-making."—*Builder*.

"More than 450 illustrations help to explain the text, which is, however, always clear and explicit, thus rendering the work an excellent *aide-memoir* for the apprentice who desires to become master of his trade."—*English Mechanic*.

Dictionary of Mechanical Engineering Terms.

LOCKWOOD'S DICTIONARY OF TERMS USED IN THE PRACTICE OF MECHANICAL ENGINEERING, embracing those current in the Drawing Office, Pattern Shop, Foundry, Fitting, Turning, Smith's and Boiler Shops, &c. &c. Comprising upwards of 6,000 Definitions. Edited by A FOREMAN PATTERN-MAKER, Author of "Pattern Making." Second Edition, Revised, with Additions. Crown 8vo, 7s. 6d. cloth.

"Just the sort of handy dictionary required by the various trades engaged in mechanical engineering. The practical engineering pupil will find the book of great value in his studies, and every foreman engineer and mechanic should have a copy."—*Building News*.

"Not merely a dictionary, but, to a certain extent, also a most valuable guide. It strikes us as a happy idea to combine with a definition of the phrase useful information on the subject of which it treats."—*Machinery Market*.

Mill Gearing.

TOOTHED GEARING: A Practical Handbook for Offices and Workshops. By A FOREMAN PATTERN MAKER, Author of "Pattern Making." "Lockwood's Dictionary of Mechanical Engineering Terms," &c. With 184 Illustrations. Crown 8vo, 6s. cloth. [Just published.]

SUMMARY OF CONTENTS.

CHAP. I. PRINCIPLES.—II. FORMATION OF TOOTH PROFILES.—III. PROPORTIONS OF TEETH.—IV. METHODS OF MAKING TOOTH FORMS.—V. INVOLUTE TEETH.—VI. SOME SPECIAL TOOTH FORMS.—VII. BEVEL WHEELS.—VIII. SCREW GEARS.—IX. WORM GEARS.—X. HELICAL WHEELS.—XI.

SKREW BEVELS.—XII. VARIABLE AND OTHER GEARS.—XIII. DIAMETRICAL PITCH.—XIV. THE ODONTOGRAPH.—XV. PATTERN GEARS.—XVI. MACHINE MOULDING GEARS.—XVII. MACHINE CUT GEARS.—XVIII. PROPORTION OF WHEELS.

"We must give the book our unqualified praise for its thoroughness of treatment, and we can heartily recommend it to all interested as the most practical book on the subject yet written."—*Mechanical World*.

Stone-working Machinery.

STONE-WORKING MACHINERY, and the Rapid and Economical Conversion of Stone. With Hints on the Arrangement and Management of Stone Works. By M. POWIS BALE, M.I.M.E. With Illusts. Crown 8vo, 9s. "The book should be in the hands of every mason or student of stone-work."—*Colliery Guardian*.

"A capital handbook for all who manipulate stone for building or ornamental purposes."—*Machinery Market*.

Pump Construction and Management.

PUMPS AND PUMPING: A Handbook for Pump Users. Being Notes on Selection, Construction and Management. By M. POWIS BALE, M.I.M.E., Author of "Woodworking Machinery," "Saw Mills," &c. Second Edition, Revised. Crown 8vo, 2s. 6d. cloth.

"The matter is set forth as concisely as possible. In fact, condensation rather than diffuseness has been the author's aim throughout; yet he does not seem to have omitted anything likely to be of use."—*Journal of Gas Lighting*.

"Thoroughly practical and simply and clearly written."—*Glasgow Herald*.

Milling Machinery, etc.

MILLING MACHINES AND PROCESSES: A Practical Treatise on Shaping Metals by Rotary Cutters, including Information on Making and Grinding the Cutters. By PAUL N. HASLUCK, Author of "Lathe-work," "Handybooks for Handicrafts," &c. With upwards of 300 Engravings, including numerous Drawings by the Author. Large crown 8vo, 352 pages, 12s. 6d. cloth.

"A new departure in engineering literature. . . . We can recommend this work to all interested in milling machines; it is what it professes to be—a practical treatise."—*Engineer*.

"A capital and reliable book, which will no doubt be of considerable service, both to those who are already acquainted with the process as well as to those who contemplate its adoption."—*Industries*.

Turning.

LATHE-WORK: A Practical Treatise on the Tools, Appliances, and Processes employed in the Art of Turning. By PAUL N. HASLUCK. Fourth Edition, Revised and Enlarged. Cr. 8vo, 5s. cloth.

"Written by a man who knows, not only how work ought to be done, but who also knows how to do it, and how to convey his knowledge to others. To all turners this book would be valuable."

—*Engineering*.

"We can safely recommend the work to young engineers. To the amateur it will simply be invaluable. To the student it will convey a great deal of useful information."—*Engineer*.

Screw-Cutting.

SCREW THREADS: And Methods of Producing Them. With Numerous Tables, and complete directions for using Screw-Cutting Lathes. By PAUL N. HASLUCK, Author of "Lathe-Work," &c. With Seventy-four Illustrations. Third Edition, Revised and Enlarged. Waistcoat-pocket size, 1s. 6d. cloth.

"Full of useful information, hints and practical criticism. Taps, dies and screwing-too's generally are illustrated and their action described."—*Mechanical World*.

"It is a complete compendium of all the details of the screw cutting lathe; in fact a *multum in parvo* on all the subjects it treats upon."—*Carpenter and Builder*.

Smith's Tables for Mechanics, etc.

TABLES, MEMORANDA, AND CALCULATED RESULTS, FOR MECHANICS, ENGINEERS, ARCHITECTS, BUILDERS, &c. Selected and Arranged by FRANCIS SMITH. Fifth Edition, thoroughly Revised and Enlarged, with a New Section of ELECTRICAL TABLES, FORMULÆ, and MEMORANDA. Waistcoat-pocket size, 1s. 6d. limp leather.

"It would, perhaps, be as difficult to make a small pocket-book selection of notes and formulas to suit ALL engineers as it would be to make a universal medicine; but Mr. Smith's waistcoat-pocket collection may be looked upon as a successful attempt."—*Engineer*.

"The best example we have ever seen of 270 pages of useful matter packed into the dimensions of a card-case."—*Building News*. "A veritable pocket treasury of knowledge."—*Iron*.

French-English Glossary for Engineers, etc.

A POCKET GLOSSARY OF TECHNICAL TERMS: ENGLISH-FRENCH, FRENCH-ENGLISH; with Tables suitable for the Architectural, Engineering, Manufacturing and Nautical Professions. By JOHN JAMES FLETCHER, Engineer and Surveyor. Second Edition, Revised and Enlarged, 200 pp. Waistcoat-pocket size, 1s. 6d. limp leather.

"It is a very great advantage for readers and correspondents in France and England to have so large a number of the words relating to engineering and manufacturers collected in a limpid volume. The little book will be useful both to students and travellers."—*Architect*.

"The glossary of terms is very complete, and many of the tables are new and well arranged. We cordially commend the book."—*Mechanical World*.

Year-Book of Engineering Formulæ, &c.

THE ENGINEER'S YEAR-BOOK FOR 1894. Comprising Formulæ, Rules, Tables, Data and Memoranda in Civil, Mechanical, Electrical, Marine and Mine Engineering. By H. R. KEMPE, A.M. Inst.C.E., M.I.E.E., Technical Officer of the Engineer-in-Chief's Office, General Post Office, London. Author of "A Handbook of Electrical Testing," "The Electrical Engineer's Pocket-Book," &c. With 700 Illustrations, specially Engraved for the work. Crown 8vo, 600 pages, 8s. leather. [Just published.] "Represents an enormous quantity of work, and forms a desirable book of reference."—*The Engineer*.

"The book is distinctly in advance of most similar publications in this country."—*Engineering*.
 "This valuable and well-designed book of reference meets the demands of all descriptions of engineers."—*Saturday Review*.

"Teems with up-to-date information in every branch of engineering and construction."—*Building News*.

"The needs of the engineering profession could hardly be supplied in a more admirable, complete and convenient form. To say that it more than sustains all comparisons is praise of the highest sort, and that may justly be said of it."—*Mining Journal*.

"There is certainly room, or the new corner, which supplies explanations and directions, as well as formulæ and tables. It deserves to become one of the most successful of the technical annuals."—*Architect*.

"Brings together with great skill all the technical information which an engineer has to use day by day. It is in every way admirably equipped, and is sure to prove successful."—*Scotsman*.

"The up-to-dateness of Mr. Kempe's compilation is a quality that will not be lost on the busy people for whom the work is intended."—*Glasgow Herald*.

Portable Engines.**THE PORTABLE ENGINE; ITS CONSTRUCTION AND**

MANAGEMENT. A Practical Manual for Owners and Users of Steam Engines generally. By WILLIAM DYSON WANSBROUGH. With 90 Illustrations. Crown 8vo, 3s. 6d. cloth.

"This is a work of value to those who use steam machinery. . . . Should be read by every one who has a steam engine, on a farm or elsewhere."—*Mark Lane Express*.

"We cordially commend this work to buyers and owners of steam engines, and to those who have to do with their construction or use."—*Timber Trades Journal*.

"Such a general knowledge of the steam engine as Mr. Wansbrough furnishes to the reader should be acquired by all intelligent owners and others who use the steam engine."—*Building News*.

"An excellent text-book of this useful form of engine." "The Hints to Purchasers" contain a good deal of commonsense and practical wisdom."—*English Mechanic*.

Iron and Steel.**"IRON AND STEEL": A Work for the Forge, Foundry, Factory,**

and Office. Containing ready, useful, and trustworthy Information for Iron-masters and their Stock-takers; Managers of Bar, Rail, Plate, and Sheet Rolling Mills; Iron and Metal Founders; Iron Ship and Bridge Builders; Mechanical, Mining, and Consulting Engineers; Architects, Contractors, Builders, and Professional Draughtsmen. By CHARLES HOARE, Author of "The Slide Rule," &c. Eighth Edition, Revised throughout and considerably Enlarged. 32mo, 6s. leather.

"For comprehensiveness the book has not its equal."—*Iron*.

"One of the best of the pocket books."—*English Mechanic*.

"We cordially recommend this book to those engaged in considering the details of all kinds of iron and steel works."—*Naval Science*.

Elementary Mechanics.**CONDENSED MECHANICS.** A Selection of Formulæ, Rules,

Tables, and Data for the Use of Engineering Students, Science Classes, &c. In Accordance with the Requirements of the Science and Art Department. By W. C. CRAWFORD HUGHES, A.M.I.C.E. Crown 8vo, 2s. 6d. cloth.

"The book is well fitted for those who are either confronted with practical problems in their work, or are preparing for examination and wish to refresh their knowledge by going through their formulæ again."—*Marine Engineer*.

"It is well arranged, and meets the wants of those for whom it is intended."—*Railway News*.

Steam.

THE SAFE USE OF STEAM. Containing Rules for Un-professional Steam-users. By an ENGINEER. Sixth Edition. Sewed, 6d.

"If steam-users would but learn this little book by heart, boiler explosions would become sensations by their rarity."—*English Mechanic*.

Warming.

HEATING BY HOT WATER; with Information and Suggestions on the best Methods of Heating Public, Private and Horticultural Buildings. By WALTER JONES. Second Edition. With 96 Illustrations. Crown 8vo, 2s. 6d. net.

"We confidently recommend all interested in heating by hot water to secure a copy of this valuable little treatise."—*The Plumber and Decorator*.

THE POPULAR WORKS OF MICHAEL REYNOLDS

("THE ENGINE DRIVER'S FRIEND")

Locomotive-Engine Driving.

LOCOMOTIVE-ENGINE DRIVING: A Practical Manual for Engineers in charge of Locomotive Engines. By MICHAEL REYNOLDS, Member of the Society of Engineers, formerly Locomotive Inspector L. B. and S. C. R. Ninth Edition. Including a KEY to the LOCOMOTIVE ENGINE. With Illustrations and Portrait of Author. Crown 8vo, 4s. 6d. cloth.

"Mr. Reynolds has supplied a want, and has supplied it well. We can confidently recommend the book, not only to the practical driver, but to everyone who takes an interest in the performance of locomotive engines."—*The Engineer*.

"Mr. Reynolds has opened a new chapter in the literature of the day. This admirable practical treatise, of the practical utility of which we have to speak in terms of warm commendation."—*Athenaeum*.

"Evidently the work of one who knows his subject thoroughly."—*Railway Service Gazette*.

"Were the cautions and rules given in the book to become part of the every-day working of our engine-drivers, we might have fewer distressing accidents to deplore."—*Scotsman*.

Stationary Engine Driving.

STATIONARY ENGINE DRIVING: A Practical Manual for Engineers in charge of Stationary Engines. By MICHAEL REYNOLDS. Fifth Edition, Enlarged. With Plates and Woodcuts. Crown 8vo, 4s. 6d. cloth.

"The author is thoroughly acquainted with his subjects, and his advice on the various points treated is clear and practical. . . . He has produced a manual which is an exceedingly useful one for the class for whom it is specially intended."—*Engineering*.

"Our author leaves no stone unturned. He is determined that his readers shall not only know something about the stationary engine, but all about it."—*Engineer*.

"An engineman who has mastered the contents of Mr. Reynolds's book will require but little actual experience with boilers and engines before he can be trusted to look after them."—*English Mechanic*.

The Engineer, Fireman, and Engine-Boy.

THE MODEL LOCOMOTIVE ENGINEER, FIREMAN, and ENGINE-BOY. Comprising a Historical Notice of the Pioneer Locomotive Engines and their Inventors. By MICHAEL REYNOLDS. With numerous Illustrations and a fine Portrait of George Stephenson. Crown 8vo, 4s. 6d. cloth.

"From the technical knowledge of the author it will appeal to the railway man of to-day more forcibly than anything written by Dr. Smiles. . . . The volume contains information of a technical kind, and facts that every driver should be familiar with."—*English Mechanic*.

"We should be glad to see this book in the possession of everyone in the kingdom who has ever laid, or is to lay, hands on a locomotive engine."—*Iron*.

Continuous Railway Brakes.

CONTINUOUS RAILWAY BRAKES: A Practical Treatise on the several Systems in Use in the United Kingdom; their Construction and Performance. With copious Illustrations and numerous Tables. By MICHAEL REYNOLDS. Large crown 8vo, 9s. cloth.

"A popular explanation of the different brakes. It will be of great assistance in forming public opinion, and will be studied with benefit by those who take an interest in the brake."—*English Mechanic*.

"Written with sufficient technical detail to enable the principle and relative connection of the various parts of each particular brake to be readily grasped."—*Mechanical World*.

Engine-Driving Life.

ENGINE-DRIVING LIFE: Stirring Adventures and Incidents in the Lives of Locomotive-Engine Drivers. By MICHAEL REYNOLDS. Third and Cheaper Edition. Crown 8vo, 1s. 6d. cloth. [Just published.]

"From first to last perfectly fascinating. Wylie Collins's most thrilling conceptions are thrown into the shade by true incidents, endless in their variety, related in every page."—*North British Mail*.

"Anyone who wishes to get a real insight into railway life cannot do better than read 'Engine-Driving Life' for himself; and if he once take it up he will find that the author's enthusiasm and real love of the engine-driving profession will carry him on till he has read every page."—*Saturday Review*.

Pocket Companion for Enginemen.

THE ENGINEMAN'S POCKET COMPANION AND PRACTICAL EDUCATOR FOR ENGINEMEN, BOILER ATTENDANTS, AND MECHANICS. By MICHAEL REYNOLDS. With Forty-five Illustrations and numerous Diagrams. Third Edition, Revised. Royal 18mo, 3s. 6d., strongly bound for pocket wear.

"This admirable work is well suited to accomplish its object, being the honest workmanship of a competent engineer."—*Glasgow Herald*.

"A most meritorious work, giving in a succinct and practical form all the information an engineman desirous of mastering the scientific principles of his daily calling would require."—*The Miller*.

"A boon to those who are striving to become efficient mechanics."—*Daily Chronicle*.

CIVIL ENGINEERING, SURVEYING, etc.

MR. HUMBER'S VALUABLE ENGINEERING BOOKS.

The Water Supply of Cities and Towns.

A COMPREHENSIVE TREATISE on the WATER-SUPPLY OF CITIES AND TOWNS. By WILLIAM HUMBER, A.M.Inst.C.E., and M. Inst. M.E., Author of "Cast and Wrought Iron Bridge Construction," &c. &c. Illustrated with 50 Double Plates, 1 Single Plate, Coloured Frontispiece, and upwards of 250 Woodcuts, and containing 400 pages of Text. Imp. 4to, £6 6s. elegantly and substantially half-bound in morocco.

List of Contents.

I. Historical Sketch of some of the means that have been adopted for the Supply of Water to Cities and Towns.—II. Water and the Foreign Matter usually associated with it.—III. Rainfall and Evaporation.—IV. Springs and the water-bearing formations of various districts.—V. Measurement and Estimation of the flow of Water.—VI. Selection of the Source of Supply.—VII. Wells.—VIII. Reservoirs.—IX. The Purification of Water.—X. Pumps.—XI. Pumping Machinery.—XII.

Conduits.—XIII. Distribution of Water.—XIV. Meters, Service Pipes, and House Fittings.—XV. The Law and Economy of Water Works.—XVI. Constant and Intermittent Supply.—XVII. Description of Plates.—Appendices, giving Tables of Rates of Supply, Velocities, &c. &c., together with Specifications of several Works illustrated, among which will be found: Aberdeen, Bideford, Canterbury, Dundee, Halifax, Lambeth, Rotherham, Dublin, and others.

"The most systematic and valuable work upon water supply hitherto produced in English, or in any other language. . . . Mr. Humber's work is characterised almost throughout by an exhaustiveness much more distinctive of French and German than of English technical treatises."—*Engineer*.

"We can congratulate Mr. Humber on having been able to give so large an amount of information on a subject so important as the water supply of cities and towns. The plates, fifty in number, are mostly drawings of executed works, and alone would have commanded the attention of every engineer whose practice may lie in this branch of the profession."—*Builder*.

Cast and Wrought Iron Bridge Construction.

A COMPLETE AND PRACTICAL TREATISE ON CAST AND WROUGHT IRON BRIDGE CONSTRUCTION, including Iron Foundations. In Three Parts—Theoretical, Practical, and Descriptive. By WILLIAM HUMBER, A.M.Inst.C.E., and M.Inst.M.E. Third Edition, Revised and much improved, with 115 Double Plates (20 of which now first appear in this edition), and numerous Additions to the Text. In Two Vols., imp. 4to, £6 16s. 6d. half-bound in morocco.

"A very valuable contribution to the standard literature of civil engineering. In addition to elevations, plans and sections, large scale details are given which very much enhance the instructive worth of those illustrations."—*Civil Engineer and Architect's Journal*.

"Mr. Humber's stately volumes, lately issued—in which the most important bridges erected during the last five years, under the direction of the late Mr. Brunel, Sir W. Cubitt, Mr. Hawkshaw, Mr. Page, Mr. Fowler, Mr. Hemans, and others among our most eminent engineers, are drawn and specified in great detail."—*Engineer*.

Strains, Calculation of.

A HANDY BOOK FOR THE CALCULATION OF STRAINS IN GIRDERS AND SIMILAR STRUCTURES, AND THEIR STRENGTH. Consisting of Formulæ and Corresponding Diagrams, with numerous details for Practical Application, &c. By WILLIAM HUMBER, A.M.Inst.C.E., &c. Fifth Edition. Crown 8vo, nearly 100 Woodcuts and 3 Plates, 7s. 6d. cloth.

"The formulæ are neatly expressed, and the diagrams good."—*Athenæum*.

"We heartily commend this really handy book to our engineer and architect readers."—*English Mechanic*.

Barlow's Strength of Materials, enlarged by Humber.

A TREATISE ON THE STRENGTH OF MATERIALS; with Rules for Application in Architecture, the Construction of Suspension Bridges, Railways, &c. By PETER BARLOW, F.R.S. A New Edition, Revised by his Sons, P. W. BARLOW, F.R.S., and W. H. BARLOW, F.R.S.; to which are added, Experiments by HODGKINSON, FAIRBAIRN, and KIRKALDY; and Formulæ for Calculating Girders, &c. Arranged and Edited by WM. HUMBER, A.M.Inst.C.E. Demy 8vo, 400 pp., with 19 large Plates and numerous Woodcuts, 18s. cloth.

"Valuable alike to the student, tyro, and the experienced practitioner, it will always rank in future, as it has hitherto done, as the standard treatise on that particular subject."—*Engineer*.

"There is no greater authority than Barlow."—*Building News*.

"As a scientific work of the first class, it deserves a foremost place on the bookshelves of every civil engineer and practical mechanic."—*English Mechanic*.

MR. HUMBER'S GREAT WORK ON MODERN ENGINEERING.

Complete in Four Volumes, imperial 4to, price £12 12s., half-morocco. Each Volume sold separately as follows:—

A RECORD OF THE PROGRESS OF MODERN ENGINEERING. FIRST SERIES. Comprising Civil, Mechanical, Marine, Hydraulic, Railway, Bridge, and other Engineering Works, &c. By WILLIAM HUMBER, A-M.Inst.C.E., &c. Imp. 4to, with 36 Double Plates, drawn to a large scale, Photographic Portrait of John Hawkshaw, C.E., F.R.S., &c., and copious descriptive Letterpress, Specifications, &c., £3 3s. half-morocco.

List of the Plates and Diagrams.

Victoria Station and Roof, L. B. & S. C. R. (8 plates); Southport Pier (2 plates); Victoria Station and Roof, L. C. & D. and G. W. R. (6 plates); Roof of Cremorne Music Hall; Bridge over G. N. Railway; Roof of Station, Dutch Rhenish Rail (2 plates); Bridge over the

Thames, West London Extension Railway (2 plates); Armour Plates: Suspension Bridge, Thames (4 plates); The Allen Engine; Suspension Bridge, Avon (3 plates); Underground Railway (3 plates).

"Handsomely lithographed and printed. It will find favour with many who desire to preserve in a permanent form copies of the plans and specifications prepared for the guidance of the contractors for many important engineering works."—*Engineer*.

HUMBER'S PROGRESS OF MODERN ENGINEERING.

SECOND SERIES. Imp. 4to, with 36 Double Plates, Photographic Portrait of Robert Stephenson, C.E., M.P., F.R.S., &c., and copious descriptive Letterpress, Specifications, &c., £3 3s. half-morocco.

List of the Plates and Diagrams.

Birkenhead Docks, Low Water Basin (25 plates); Charing Cross Station Roof, C. C. Railway (3 plates); Digswell Viaduct, Great Northern Railway; Robbery Wood Viaduct, Great Northern Railway; Iron Permanent Way; Clydach Viaduct, Merthyr, Tredegar,

and Aberavenny Railway; Ebbw Viaduct, Merthyr, Tredegar, and Aberavenny Railway; College Wood Viaduct, Cornwall Railway; Dublin Winter Palace Roof (3 plates); Bridge over the Thames, L. C. & D. Railway (6 plates); Albert Harbour, Greenock (4 plates).

"Mr. Humber has done the profession good and true service, by the fine collection of examples he has here brought before the profession and the public."—*Practical Mechanic's Journal*.

HUMBER'S PROGRESS OF MODERN ENGINEERING.

THIRD SERIES. Imp. 4to, with 40 Double Plates, Photographic Portrait of J. R. McClean, late Pres. Inst. C.E., and copious descriptive Letterpress, Specifications, &c., £3 3s. half-morocco.

List of the Plates and Diagrams.

MAIN DRAINAGE, METROPOLIS.—North Side.—Map showing Interception of Sewers; Middle Level Sewer (2 plates); Outfall Sewer, Bridge over River Lea (3 plates); Outfall Sewer, Bridge over Marsh Lane, North Woolwich Railway, and Bow and Barking Railway Junction; Outfall Sewer, Bridge over Bow and Barking Railway (3 plates); Outfall Sewer, Bridge over East London Waterworks Feeder (2 plates); Outfall Sewer, Reservoir (2 plates); Outfall Sewer, Tumbling Bay and Outlet; Outfall Sewer, Penstocks. **South Side.**—Outfall Sewer, Bermondsey Branch (2 plates); Outfall

Sewer, Reservoir and Outlet (4 plates); Outfall Sewer, Filth Hoist; Sections of Sewers (North and South Sides).

THAMES EMBANKMENT.—Section of River Wall; Steamboat Pier, Westminster (2 plates); Landing Stairs between Charing Cross and Waterloo Bridges; York Gate (2 plates); Overflow and Outlet at Savoy Street Sewer (3 plates); Steamboat Pier, Waterloo Bridge (3 plates); Junction of Sewers, Plans and Sections; Gullies, Plans and Sections; Rolling Stock; Granite and Iron Forts.

"The drawings have a constantly increasing value, and whoever desires to possess clear representations of the two great works carried out by our Metropolitan Board will obtain Mr. Humber's volume."—*Engineer*.

HUMBER'S PROGRESS OF MODERN ENGINEERING.

FOURTH SERIES. Imp. 4to, with 36 Double Plates, Photographic Portrait of John Fowler, late Pres. Inst. C.E., and copious descriptive Letterpress, Specifications, &c., £3 3s. half-morocco.

List of the Plates and Diagrams.

Abbey Mills Pumping Station, Main Drainage, Metropolis (4 plates); Barrow Docks (5 plates); Manquits Viaduct, Santiago and Valparaiso Railway (2 plates); Adam's Locomotive, St. Helen's Canal Railway (2 plates); Cannon Street Station Roof, Charing Cross Railway (3 plates); Road Bridge over the River Moka (2 plates); Telegraphic Apparatus for

Mesopotamia; Viaduct over the River Wye, Midland Railway (3 plates); St. Germans Viaduct, Cornwall Railway (2 plates); Wrought-iron Cylinder for Diving Bell; Millwall Docks (6 plates); Milroy's Patent Excavator; Metropolitan District Railway (6 plates); Harbours, Forts, and Breakwaters (3 plates).

"We gladly welcome another year's issue of this valuable publication from the able pen of Mr. Humber. The accuracy and general excellence of this work are well known, while its usefulness in giving the measurements and details of some of the latest examples of engineering, as carried out by the most eminent men in the profession, cannot be too highly prized."—*Artisan*.

Statics, Graphic and Analytic.

GRAPHIC AND ANALYTIC STATICS, in their Practical Application to the Treatment of Stresses in Roofs, Solid Girders, Lattices, Bowstring and Suspension Bridges, Braced Iron Arches and Piers, and other Frameworks. By R. HUDSON GRAHAM, C.E. Containing Diagrams and Plates to Scale. With numerous Examples, many taken from existing Structures. Specially arranged for Class-work in Colleges and Universities. Second Edition, Revised and Enlarged. 8vo, 16s. cloth.

"Mr. Graham's book will find a place wherever graphic and analytic statics are used or studied."
—*Engineer*.

"The work is excellent from a practical point of view, and has evidently been prepared with much care. The directions for working are ample, and are illustrated by an abundance of well-selected examples. It is an excellent text-book for the practical draughtsman."—*Athenaeum*.

Practical Mathematics.

MATHEMATICS FOR PRACTICAL MEN: Being a Common-place Book of Pure and Mixed Mathematics. Designed chiefly for the use of Civil Engineers, Architects and Surveyors. By OLINTHUS GREGORY, LL.D., F.R.A.S., Enlarged by HENRY LAW, C.E. 4th Edition, carefully Revised by J. R. YOUNG, formerly Professor of Mathematics, Belfast College. With 13 Plates. 8vo, £1 1s. cloth.

"The engineer or architect will here find ready to his hand rules for solving nearly every mathematical difficulty that may arise in his practice. The rules are in all cases explained by means of examples, in which every step of the process is clearly worked out."—*Builder*.

"One of the most serviceable books for practical mechanics. . . . It is an instructive book for the student, and a text-book for him who, having once mastered the subjects it treats of, needs occasionally to refresh his memory upon them."—*Building News*.

Hydraulic Tables.

HYDRAULIC TABLES, CO-EFFICIENTS, and FORMULÆ for finding the Discharge of Water from Orifices, Notches, Weirs, Pipes, and Rivers. With New Formulas, Tables, and General Information on Rainfall, Catchment-Basins, Drainage, Sewerage, Water Supply for Towns and Mill Power. By JOHN NEVILLE, Civil Engineer, M.R.I.A. Third Ed., carefully Revised, with considerable Additions. Numerous Illustrations. Cr. 8vo, 14s. cloth.

"Alike valuable to students and engineers in practice; its study will prevent the annoyance of avoidable failures, and assist them to select the readiest means of successfully carrying out any given work connected with hydraulic engineering."—*Mining Journal*.

"It is, of all English books on the subject, the one nearest to completeness. . . . From the good arrangement of the matter, the clear explanations, and abundance of formulae, the carefully calculated tables, and, above all, the thorough acquaintance with both theory and construction, which is displayed from first to last, the book will be found to be an acquisition."—*Architect*.

Hydraulics.

HYDRAULIC MANUAL. Consisting of Working Tables and Explanatory Text. Intended as a Guide in Hydraulic Calculations and Field Operations. By LOWIS D'A. JACKSON, Author of "Aid to Survey Practice," "Modern Metrology," &c. Fourth Edition, Enlarged. Large cr. 8vo, 16s. cl.

"The author has had a wide experience in hydraulic engineering and has been a careful observer of the facts which have come under his notice, and from the great mass of material at his command he has constructed a manual which may be accepted as a trustworthy guide to this branch of the engineer's profession. We can heartily recommend this volume to all who desire to be acquainted with the latest development of this important subject."—*Engineering*.

"The standard-work in this department of mechanics."—*Scottsman*.

"The most useful feature of this work is its freedom from what is superannuated, and its thorough adoption of recent experiments; the text is, in fact, in great part a short account of the great modern experiments."—*Nature*.

Drainage.

ON THE DRAINAGE OF LANDS, TOWNS, AND BUILDINGS. By G. D. DEMPSEY, C.E., Author of "The Practical Railway Engineer," &c. Revised, with large Additions on RECENT PRACTICE IN DRAINAGE ENGINEERING, by D. KINNEAR CLARK, M.Inst.C.E. Author of "Tramways: Their Construction and Working," "A Manual of Rules, Tables, and Data for Mechanical Engineers," &c. Second Edition, Corrected. Fcap. 8vo, 5s. cloth.

"The new matter added to Mr. Dempsey's excellent work is characterised by the comprehensive grasp and accuracy of detail for which the name of Mr. D. K. Clark is a sufficient voucher."—*Athenaeum*.

"As a work on recent practice in drainage engineering, the book is to be commended to all who are making that branch of engineering science their special study."—*Iron*.

"A comprehensive manual on drainage engineering, and a useful introduction to the student."—*Building News*.

Water Storage, Conveyance, and Utilisation.

WATER ENGINEERING: A Practical Treatise on the Measurement, Storage, Conveyance, and Utilisation of Water for the Supply of Towns, for Mill Power, and for other Purposes. By CHARLES SLAGG, Water and Drainage Engineer, A.M.Inst.C.E., Author of "Sanitary Work in the Smaller Towns, and in Villages," &c. With numerous Illustrations. Cr. 8vo, 7s. 6d. cloth.

"As a small practical treatise on the water supply of towns, and on some applications of water-power, the work is in many respects excellent."—*Engineering*.

"The author has collated the results deduced from the experiments of the most eminent authorities, and has presented them in a compact and practical form, accompanied by very clear and detailed explanations. . . . The application of water as a motive power is treated very carefully and exhaustively."—*Builder*.

"For anyone who desires to begin the study of hydraulics with a consideration of the practical applications of the science there is no better guide."—*Architect*.

River Engineering.

RIVER BARS: The Causes of their Formation, and their Treatment by "Induced Tidal Scour;" with a Description of the Successful Reduction by this Method of the Bar at Dublin. By I. J. MANN, Assist. Eng. to the Dublin Port and Docks Board. Royal 8vo, 7s. 6d. cloth.

"We recommend all interested in harbour works—and, indeed, those concerned in the improvements of rivers generally—to read Mr. Mann's interesting work on the treatment of river bars."—*Engineer*.

Trusses.

TRUSSES OF WOOD AND IRON. Practical Applications of Science in Determining the Stresses, Breaking Weights, Safe Loads, Scantlings, and Details of Construction, with Complete Working Drawings. By WILLIAM GRIFFITHS, Surveyor, Assistant Master, Tranmere School of Science and Art. Oblong 8vo, 4s. 6d. cloth.

"This handy little book enters so minutely into every detail connected with the construction of roof trusses, that no student need be ignorant of these matters."—*Practical Engineer*.

Railway Working.

SAFE RAILWAY WORKING. A Treatise on Railway Accidents: Their Cause and Prevention; with a Description of Modern Appliances and Systems. By CLEMENT E. STRETTON, C.E., Vice-President and Consulting Engineer, Amalgamated Society of Railway Servants. With Illustrations and Coloured Plates. Third Edition, Enlarged. Crown 8vo, 3s. 6d. cloth.

"A book for the engineer, the directors, the managers; and, in short, all who wish for information on railway matters will find a perfect encyclopædia in 'Safe Railway Working.'"—*Railway Review*.

"We commend the remarks on railway signalling to all railway managers, especially where a uniform code and practice is advocated."—*Herepath's Railway Journal*.

"The author may be congratulated on having collected, in a very convenient form, much valuable information on the principal questions affecting the safe working of railways."—*Railway Engineer*.

Oblique Bridges.

A PRACTICAL AND THEORETICAL ESSAY ON OBLIQUE BRIDGES. With 13 large Plates. By the late GEORGE WATSON BUCK, M.I.C.E. Third Edition, revised by his Son, J. H. WATSON BUCK, M.I.C.E.; and with the addition of Description to Diagrams for Facilitating the Construction of Oblique Bridges, by W. H. BARLOW, M.I.C.E. Royal 8vo, 12s. cloth.

"The standard text-book for all engineers regarding skew arches is Mr. Buck's treatise, and it would be impossible to consult a better."—*Engineer*.

"Mr. Buck's treatise is recognised as a standard text-book, and his treatment has divested the subject of many of the intricacies supposed to belong to it. As a guide to the engineer and architect, on a confessedly difficult subject, Mr. Buck's work is unsurpassed."—*Building News*.

Tunnel Shafts.

THE CONSTRUCTION OF LARGE TUNNEL SHAFTS: A Practical and Theoretical Essay. By J. H. WATSON BUCK, M.Inst.C.E., Resident Engineer, London and North-Western Railway. Illustrated with Folding Plates. Royal 8vo, 12s. cloth.

"Many of the methods given are of extreme practical value to the mason; and the observations on the form of arch, the rules for ordering the stone, and the construction of the templates will be found of considerable use. We commend the book to the engineering profession."—*Building News*.

"Will be regarded by civil engineers as of the utmost value, and calculated to save much time and obviate many mistakes."—*Colliery Guardian*.

Student's Text-Book on Surveying.

PRACTICAL SURVEYING: A Text-Book for Students preparing for Examination or for Survey-work in the Colonies. By GEORGE W. USILL, A.M.I.C.E., Author of "The Statistics of the Water Supply of Great Britain." With Four Lithographic Plates and upwards of 330 Illustrations. Third Edition, Revised and Enlarged. Including Tables of Natural Sines, Tangents, Secants, &c. Crown 8vo, 7s. 6d. cloth; or, on THIN PAPER, bound in limp leather, gilt edges, rounded corners, for pocket use, 12s. 6d.

"The best forms of instruments are described as to their construction, uses and modes of employment, and there are innumerable hints on work and equipment such as the author, in his experience as surveyor, draughtsman, and teacher, has found necessary, and which the student in his inexperience will find most serviceable."—*Engineer*.

"The latest treatise in the English language on surveying, and we have no hesitation in saying that the student will find it a better guide than any of its predecessors. Deserves to be recognised as the first book which should be put in the hands of a pupil of Civil Engineering, and every gentleman of education who sets out for the Colonies would find it well to have a copy."—*Architect*.

Survey Practice.

AID TO SURVEY PRACTICE, for Reference in Surveying, Levelling, and Setting-out; and in Route Surveys of Travellers by Land and Sea. With Tables, Illustrations, and Records. By LOWIS D'A. JACKSON, A.M.I.C.E., Author of "Hydraulic Manual," "Modern Metrology," &c. Second Edition, Enlarged. Large crown 8vo, 12s. 6d. cloth.

"A valuable *vade-mecum* for the surveyor. We can recommend this book as containing an admirable supplement to the teaching of the accomplished surveyor."—*Athenæum*.

"As a text-book we should advise all surveyors to place it in their libraries, and study well the matured instructions afforded in its pages."—*Cobden's Guardian*.

"The author brings to his work a fortunate union of theory and practical experience which, aided by a clear and lucid style of writing, renders the book a very useful one."—*Builder*.

Surveying, Land and Marine.

LAND AND MARINE SURVEYING, in Reference to the Preparation of Plans for Roads and Railways; Canals, Rivers, Towns' Water Supplies; Docks and Harbours. With Description and Use of Surveying Instruments. By W. D. HASKOLL, C.E., Author of "Bridge and Viaduct Construction," &c. Second Edition, Revised, with Additions. Large cr. 8vo, 9s. cl.

"This book must prove of great value to the student. We have no hesitation in recommending it, feeling assured that it will more than repay a careful study."—*Mechanical World*.

"A most useful and well arranged book. We can strongly recommend it as a carefully-written and valuable text-book. It enjoys a well-deserved repute among surveyors."—*Builder*.

"This volume cannot fail to prove of the utmost practical utility. It may be safely recommended to all students who aspire to become clean and expert surveyors."—*Mining Journal*.

Field-Book for Engineers.

THE ENGINEER'S, MINING SURVEYOR'S, AND CON-TRACTOR'S FIELD-BOOK. Consisting of a Series of Tables, with Rules, Explanations of Systems, and use of Theodolite for Traverse Surveying and Plotting the Work with minute accuracy by means of Straight Edge and Set Square only; Levelling with the Theodolite, Casting-out and Reducing Levels to Datum, and Plotting Sections in the ordinary manner; setting-out Curves with the Theodolite by Tangential Angles and Multiples, with Right and Left-hand Readings of the Instrument; Setting-out Curves without Theodolite, on the System of Tangential Angles by sets of Tangents and Off-sets; and Earthwork Tables to 80 feet deep, calculated for every 6 inches in depth. By W. D. HASKOLL, C.E. Fourth Edition. Crown 8vo, 12s. cloth.

"The book is very handy; the separate tables of sines and tangents to every minute will make it useful for many other purposes, the genuine traverse tables existing all the same."—*Athenæum*.

"Every person engaged in engineering field operations will estimate the importance of such a work and the amount of valuable time which will be saved by reference to a set of reliable tables prepared with the accuracy and fullness of those given in this volume."—*Railway News*.

Levelling.

A TREATISE ON THE PRINCIPLES AND PRACTICE OF LEVELLING. Showing its Application to purposes of Railway and Civil Engineering, in the Construction of Roads; with Mr. TELFORD'S Rules for the same. By FREDERICK W. SIMMS, F.G.S., M.Inst.C.E. Seventh Edition, with the addition of LAW'S Practical Examples for Setting-out Railway Curves, and TRAUTWINE'S Field Practice of Laying-out Circular Curves. With 7 Plates and numerous Woodcuts. 8vo, 8s. 6d. cloth. *TRAUTWINE on Curves may be had separate, 5s.

"The text-book on levelling in most of our engineering schools and colleges."—*Engineer*.

"The publishers have rendered a substantial service to the profession, especially to the younger members, by bringing out the present edition of Mr. Simms's useful work."—*Engineer*.

Trigonometrical Surveying.

AN OUTLINE OF THE METHOD OF CONDUCTING A TRIGONOMETRICAL SURVEY, for the Formation of Geographical and Topographical Maps and Plans, Military Reconnaissance, Levelling, &c., with Useful Problems, Formulae, and Tables. By Lieut-General FROME, R.E. Fourth Edition, Revised and partly Re-written by Major General Sir CHARLES WARREN, G.C.M.G., R.E. With 19 Plates and 115 Woodcuts. Royal 8vo, 16s. cloth.

"The simple fact that a fourth edition has been called for is the best testimony to its merits. No words of praise from us can strengthen the position so well and so steadily maintained by this work. Sir Charles Warren has revised the entire work, and made such additions as were necessary to bring every portion of the contents up to the present date."—*Broad Arrow*.

Field Fortification.

A TREATISE ON FIELD FORTIFICATION, THE ATTACK OF FORTRESSES, MILITARY MINING, AND RECONNOITRING. By Colonel I. S. MACAULAY, late Professor of Fortification in the R.M.A., Woolwich. Sixth Edition. Crown 8vo, with separate Atlas of 12 Plates, 12s. cloth.

Tunnelling.

PRACTICAL TUNNELLING. Explaining in detail the Setting-out of the works, Shaft-sinking and Heading-driving, Ranging the Lines and Levelling underground, Sub-Excavating, Timbering, and the Construction of the Brickwork of Tunnels, with the amount of Labour required for, and the Cost of, the various portions of the work. By FREDERICK W. SIMMS, F.G.S., M.Inst.C.E. Third Edition, Revised and Extended by D. KINNAR CLARK, M.Inst.C.E. Imperial 8vo, with 21 Folding Plates and numerous Wood Engravings, 30s. cloth.

"The estimation in which Mr. Simms's book on tunnelling has been held for over thirty years cannot be more truly expressed than in the words of the late Prof. Rankine:—'The best source of information or the subject of tunnels is Mr. F. W. Simms's work on Practical Tunnelling.'"—*Architect*.

"It has been regarded from the first as a text-book of the subject. . . . Mr. Clark has added immensely to the value of the book."—*Engineer*.

Tramways and their Working.

TRAMWAYS: THEIR CONSTRUCTION AND WORKING. Embracing a Comprehensive History of the System; with an exhaustive Analysis of the various Modes of Traction, including Horse-Power, Steam, Cable Traction, Electric Traction, &c.; a Description of the Varieties of Rolling Stock; and ample Details of Cost and Working Expenses. New Edition, Thoroughly Revised, and Including the Progress recently made in Tramway Construction, &c. &c. By D. KINNAR CLARK, M.Inst.C.E. With numerous Illustrations and Folding Plates. In One Volume, 8vo, 700 pages, price about 25s. [Nearly ready.]

"All interested in tramways must refer to it, as all railway engineers have turned to the author's work 'Railway Machinery.'"—*Engineer*.

"An exhaustive and practical work on tramways, in which the history of this kind of locomotion, and a description and cost of the various modes of laying tramways, are to be found."—*Building News*.

"The best form of rails, the best mode of construction, and the best mechanical appliances are so fairly indicated in the work under review, that any engineer about to construct a tramway will be enabled at once to obtain the practical information which will be of most service to him."—*Athenaeum*.

Curves, Tables for Setting-out.

TABLES OF TANGENTIAL ANGLES AND MULTIPLES for Setting-out Curves from 5 to 200 Radius. By ALEXANDER BEAZELEY, M.Inst.C.E. Fourth Edition. Printed on 48 Cards, and sold in a cloth box, waistcoat-pocket size, 3s. 6d.

"Each table is printed on a small card, which, being placed on the theodolite, leaves the hands free to manipulate the instrument—no small advantage as regards the rapidity of work."—*Engineer*.

"Very handy; a man may know that all his day's work must fall on two of these cards, which he puts into his own card-case, and leaves the rest behind."—*Athenaeum*.

Earthwork.

EARTHWORK TABLES. Showing the Contents in Cubic Yards of Embankments, Cuttings, &c., of Heights or Depths up to an average of 80 feet. By JOSEPH BROADBENT, C.E., and FRANCIS CAMPIN, C.E. Crown 8vo, 5s. cloth.

"The way in which accuracy is attained, by a simple division of each cross section into three elements, two in which are constant and one variable, is ingenious."—*Athenaeum*.

Heat, Expansion by.

EXPANSION OF STRUCTURES BY HEAT. By JOHN KELLY, C.E., late of the Indian Public Works and Victorian Railway Departments. Crown 8vo, 3s. 6d. cloth.

SUMMARY OF CONTENTS.

Section I. FORMULAS AND DATA.

Section II. METAL BARS.

Section III. SIMPLE FRAMES.

Section IV. COMPLEX FRAMES AND PLATES.

Section V. THERMAL CONDUCTIVITY.

Section VI. MECHANICAL FORCE OF HEAT.

Section VII. WORK OF EXPANSION AND CONTRACTION.

Section VIII. SUSPENSION BRIDGES.

Section IX. MASONRY STRUCTURES.

"The aim the author has set before him, viz., to show the effects of heat upon metallic and other structures, is a laudable one, for this is a branch of physics upon which the engineer or architect can find but little reliable and comprehensive data in books."—*Builder*.

"Whoever is concerned to know the effect of changes of temperature on such structures as suspension bridges and the like, could not do better than consult Mr. Kelly's valuable and handy exposition of the geometrical principles involved in these changes."—*Scottman*.

Earthwork, Measurement of.

A MANUAL ON EARTHWORK. By ALEX. J. S. GRAHAM, C.E. With numerous Diagrams. Second Edition. 18mo, 2s. 6d. cloth.

"A great amount of practical information, very admirably arranged, and available for rough estimates, as well as for the more exact calculations required in the engineer's and contractor's offices."—*Architect*.

Strains in Ironwork.

THE STRAINS ON STRUCTURES OF IRONWORK; with Practical Remarks on Iron Construction. By F. W. SHEILDS, M.Inst.C.E. Second Edition, with 5 Plates. Royal 8vo, 5s. cloth.

The student cannot find a better little book on this subject."—*Engineer*.

Cast Iron and other Metals, Strength of.

A PRACTICAL ESSAY ON THE STRENGTH OF CAST IRON AND OTHER METALS. By THOMAS TREDGOLD, C.E. Fifth Edition, including HODGKINSON'S Experimental Researches. 8vo, 12s. cloth.

Oblique Arches.

A PRACTICAL TREATISE ON THE CONSTRUCTION OF OBLIQUE ARCHES. By JOHN HART. Third Edition, with Plates. Imperial 8vo, 8s. cloth.

Girders, Strength of.

GRAPHIC TABLE FOR FACILITATING THE COMPUTATION OF THE WEIGHTS OF WROUGHT IRON AND STEEL GIRDERS, &c., for Parliamentary and other Estimates. By J. H. WATSON BUCK, M.Inst.C.E. On a Sheet, 2s. 6d.

Water Supply and Water-Works.

THE WATER SUPPLY OF TOWNS AND THE CONSTRUCTION OF WATER-WORKS: A Practical Treatise for the Use of Engineers and Students of Engineering. By W. K. BURTON, A.M.Inst.C.E., Professor of Sanitary Engineering in the Imperial University, Tokyo, Japan, Engineer to the Sanitary Bureau, Home Department, Japan. To which is Appended a Paper on the Effects of Earthquakes on Waterworks, by Professor JOHN MILNE, F.R.S. With numerous Plates and other Illustrations. Super-royal 8vo, 25s. buckram. [Just published.

MARINE ENGINEERING, SHIPBUILDING, NAVIGATION, etc.

Pocket-Book for Naval Architects and Shipbuilders.

THE NAVAL ARCHITECT'S AND SHIPBUILDER'S POCKET-BOOK of Formulae, Rules, and Tables, and MARINE ENGINEER'S AND SURVEYOR'S Handy Book of Reference. By CLEMENT MACKROW, Member of the Institution of Naval Architects, Naval Draughtsman. Fifth Edition, Revised and Enlarged to 700 pages, with upwards of 300 Illustrations. Fcap., 12s. 6d. strongly bound in leather.

SUMMARY OF CONTENTS.

SIGNS AND SYMBOLS, DECIMAL FRACTIONS.—TRIGONOMETRY.—PRACTICAL GEOMETRY.—MENSURATION.—CENTRES AND MOMENTS OF FIGURES.—MOMENTS OF INERTIA AND RADII OF GYRATION.—ALGEBRAICAL EXPRESSIONS FOR SIMPSON'S RULES.—MECHANICAL PRINCIPLES.—CENTRE OF GRAVITY.—LAWS OF MOTION.—DISPLACEMENT, CENTRE OF BUOYANCY.—CENTRE OF GRAVITY OF SHIP'S HULL.—STABILITY CURVES AND METACENTRES.—SEA AND SHALLOW-WATER WAVES.—ROLLING OF SHIPS.—PROPULSION AND RESISTANCE OF VESSELS.—SPEED TRIALS.—SAILING, CENTRE OF EFFORT.—DISTANCES DOWN RIVERS, COAST LINES.—STEERING AND RUDERS OF VESSELS.—LAUNCHING CALCULATIONS AND VELOCITIES.—WEIGHT OF MATERIAL AND GEAR.—GUN PARTICULARS AND WEIGHT.—STANDARD GAUGES.—RIVETED JOINTS AND RIVETING.—STRENGTH AND TESTS OF MATERIALS.—BINDING AND SHEARING STRESSES, ETC.—STRENGTH OF SHAFTING, FILLARS, WHEELS, ETC.—HYDRAULIC DATA, ETC.—CONIC SECTIONS, CATENARIAN CURVES.—MECHANICAL POWERS, WORK.—BOARD OF TRADE REGULATIONS FOR BOILERS AND ENGINES.—BOARD OF TRADE REGULATIONS FOR SHIPS.—LLOYD'S RULES

FOR BOILERS.—LLOYD'S WEIGHT OF CHAINS.—LLOYD'S SCANTLINGS FOR SHIPS.—DATA OF ENGINES AND VESSELS.—SHIPS' FITTINGS AND TESTS.—SEASONING PRESERVING TIMBER.—MEASUREMENT OF TIMBER.—ALLOYS, PAINTS, VARNISHES.—DATA FOR STOWAGE.—ADMIRALTY TRANSPORT REGULATIONS.—RULES FOR HORSE-POWER, SCREW PROPELLERS, ETC.—PERCENTAGES FOR BUTT STRAPS, ETC.—PARTICULARS OF YACHTS.—MASTING AND RIGGING VESSELS.—DISTANCES OF FOREIGN PORTS.—TONNAGE TABLES.—VOCABULARY OF FRENCH AND ENGLISH TERMS.—ENGLISH WEIGHTS AND MEASURES.—FOREIGN WEIGHTS AND MEASURES.—DECIMAL EQUIVALENTS.—FOREIGN MONEY.—DISCOUNT AND WAGE TABLES.—USEFUL NUMBERS AND READY RECKONERS.—TABLES OF CIRCULAR MEASURES.—TABLES OF AREAS OF AND CIRCUMFERENCES OF CIRCLES.—TABLES OF AREAS OF SEGMENTS OF CIRCLES.—TABLES OF SQUARES AND CUBES AND ROOTS OF NUMBERS.—TABLES OF LOGARITHMS OF NUMBERS.—TABLES OF HYPERBOLIC LOGARITHMS.—TABLES OF NATURAL SINES, TANGENTS, ETC.—TABLES OF LOGARITHMIC SINES, TANGENTS, ETC.

"In these days of advanced knowledge a work like this is of the greatest value. It contains a vast amount of information. We unhesitatingly say that it is the most valuable compilation for its specific purpose that has ever been printed. No naval architect, engineer, surveyor, or seaman, wood or iron shipbuilder, can afford to be without this work."—*Nautical Magazine*.

"Should be used by all who are engaged in the construction or designs of vessels. . . . Will be found to contain the most useful tables and formulae required by shipbuilders, carefully collected from the best authorities, and put together in a popular and simple form."—*Engineer*.

"The professional shipbuilder has now, in a convenient and accessible form, reliable data for solving many of the numerous problems that present themselves in the course of his work."—*Iron*.

"There is no doubt that a pocket-book of this description must be a necessity in the shipbuilding trade. . . . The volume contains a mass of useful information clearly expressed and presented in a handy form."—*Marine Engineer*.

Marine Engineering.

MARINE ENGINES AND STEAM VESSELS (A Treatise

on). By ROBERT MURRAY, C.E. Eighth Edition, thoroughly Revised, with considerable Additions by the Author and by GEORGE CARLISLE, C.E., Senior Surveyor to the Board of Trade at Liverpool. 12mo, 5s. cloth boards.

"Well adapted to give the young steamship engineer or marine engine and boiler maker a general introduction into his practical work."—*Mechanical World*.

"We feel sure that this thoroughly revised edition will continue to be as popular as the first as it has been in the past, as, for its size, it contains more useful information than any similar treatise."—*Industries*.

"As a compendious and useful guide to engineers of our mercantile and royal naval services, we should say it cannot be surpassed."—*Building News*.

"The information given is both sound and sensible, and well qualified to direct young seagoing hands on the straight road to the extra chief's certificate. . . . Most useful to surveyors, inspectors, draughtsmen, and young engineers."—*Glasgow Herald*.

Pocket-Book for Marine Engineers.

A POCKET-BOOK OF USEFUL TABLES AND FORMULÆ FOR MARINE ENGINEERS. By FRANK PROCTOR, A.I.N.A. Third Edition. Royal 32mo, leather, gilt edges, with strap, 4s.

"We recommend it to our readers as long felt want."—*Naval Science*.

"A most useful companion to all marine engineers."—*United Service Gazette*.

Introduction to Marine Engineering.

ELEMENTARY ENGINEERING: A Manual for Young Marine Engineers and Apprentices. In the Form of Questions and Answers on Metals, Alloys, Strength of Materials, Construction and Management of Marine Engines and Boilers, Geometry, &c. &c. With an Appendix of Useful Tables. By JOHN SHERREN BREWER, Government Marine Surveyor, Hong-kong. Second Edition, Revised. Small crown 8vo, 2s. cloth.

"Contains much valuable information for the class for whom it is intended, especially in the chapters on the management of boilers and engines."—*Nautical Magazine*.

"A useful introduction to the more elaborate text-books."—*Swissman*.

"To a student who has the requisite desire and resolve to attain a thorough knowledge, Mr. Brewer offers decidedly useful help."—*Athenaeum*.

Navigation.

PRACTICAL NAVIGATION. Consisting of THE SAILOR'S SEA-BOOK, by JAMES GREENWOOD and W. H. ROSSER; together with the requisite Mathematical and Nautical Tables for the Working of the Problems, by HENRY LAW, C.E., and Professor J. R. YOUNG. Illustrated. 12mo, 7s. strongly half-bound.

Drawing for Marine Engineers.

LOCKIE'S MARINE ENGINEER'S DRAWING-BOOK. Adapted to the Requirements of the Board of Trade Examinations. By JOHN LOCKIE, C.E. With 22 Plates, Drawn to Scale. Royal 8vo, 3s. 6d. cloth.

"The student who learns from these drawings will have nothing to unlearn."—*Engineer*.

"The examples chosen are essentially practical, and are such as should prove of service to engineers generally, while admirably fulfilling their specific purpose."—*Mechanical World*.

Sailmaking.

THE ART AND SCIENCE OF SAILMAKING. By SAMUEL B. SADLER, Practical Sailmaker, late in the employment of Messrs. Ratsey and Laphorne, of Cowes and Gosport. With Plates and other Illustrations. Small 4to, 12s. 6d. cloth.

SUMMARY OF CONTENTS.

CHAP. I. THE MATERIALS USED AND THEIR RELATION TO SAILS.—II. ON THE CENTRE OF EFFORT.—III. ON MEASURING.—IV. ON DRAWING.—V. ON THE NUMBER OF CLOTHS REQUIRED.

—VI. ON ALLOWANCES.—VII. CALCULATION OF GORES.—VIII. ON CUTTING OUT.—IX. ON ROPING.—X. ON DIAGONAL-CUT SAILS.—XI. CONCLUDING REMARKS.

"This work is very ably written, and is illustrated by diagrams and carefully-worked calculations. The work should be in the hands of every sailmaker, whether employer or employed, as it cannot fail to assist them in the pursuit of their important avocations."—*Isle of Wight Herald*.

"This extremely practical work gives a complete education in all the branches of the manufacture, cutting out, roping, seaming, and goring. It is copiously illustrated, and will form a first-rate text-book and guide."—*Portsmouth Times*.

"The author of this work has rendered a distinct service to all interested in the art of sail-making. The subject of which he treats is a congenial one. Mr. Sadler is a practical sailmaker, and has devoted years of careful observation and study to the subject; and the results of the experience thus gained he has set forth in the volume before us."—*Steamship*.

Chain Cables.

CHAIN CABLES AND CHAINS. Comprising Sizes and Curves of Links, Studs, &c., Iron for Cables and Chains, Chain Cable and Chain Making, Forming and Welding Links, Strength of Cables and Chains, Certificates for Cables, Marking Cables, Prices of Chain Cables and Chains, Historical Notes, Acts of Parliament, Statutory Tests, Charges for Testing, List of Manufacturers of Cables, &c. &c. By THOMAS W. TRAILL, F.E.R.N., M. Inst. C.E., Engineer Surveyor in Chief, Board of Trade, Inspector of Chain Cable and Anchor Proving Establishments, and General Superintendent, Lloyd's Committee on Proving Establishments. With numerous Tables, Illustrations and Lithographic Drawings. Folio, £2 2s. cloth, bevelled boards.

It contains a vast amount of valuable information. Nothing seems to be wanting to make it a complete and standard work of reference on the subject."—*Nautical Magazine*.

MINING AND METALLURGY.

Mining Machinery.

MACHINERY FOR METALLIFEROUS MINES: A Practical Treatise for Mining Engineers, Metallurgists, and Managers of Mines. By E. HENRY DAVIES, M.E., F.G.S. Crown 8vo, 530 pp., with upwards of 300 Illustrations, 12s. 6d. cloth. [Just published.]

"Mr. Davies, in this handsome volume, has done the advanced student and the manager of mines good service. Almost every kind of machinery in actual use is carefully described, and the woodcuts and plates are good."—*Athenæum*.

"From cover to cover the work exhibits all the same characteristics which excite the confidence and attract the attention of the student as he peruses the first page. The work may safely be recommended. By its publication the literature connected with the industry will be enriched, and the reputation of its author enhanced."—*Mining Journal*.

"Mr. Davies has endeavoured to bring before his readers the best of everything in modern mining appliances. His work carries internal evidence of the author's impartiality, and this constitutes one of the great merits of the book. Throughout his work the criticisms are based on his own or other reliable experience."—*Iron and Steel Trades' Journal*.

"The work deals with nearly every class of machinery or apparatus likely to be met with or required in connection with metalliferous mining, and is one which we have every confidence in recommending."—*Practical Engineer*.

Metalliferous Minerals and Mining.

A TREATISE ON METALLIFEROUS MINERALS AND MINING. By D. C. DAVIES, F.G.S., Mining Engineer, &c., Author of "A Treatise on Slate and Slate Quarrying." Fifth Edition, thoroughly Revised and much Enlarged, by his Son, E. HENRY DAVIES, M.E., F.G.S. With about 150 Illustrations. Crown 8vo, 12s. 6d. cloth.

"Neither the practical miner nor the general reader interested in mines can have a better book for his companion and his guide."—*Mining Journal*.

"We are doing our readers a service in calling their attention to this valuable work."—*Mining World*.

"A book that will not only be useful to the geologist, the practical miner, and the metallurgist but also very interesting to the general public."—*Iron*.

"As a history of the present state of mining throughout the world this book has a real value and it supplies an actual want."—*Athenæum*.

Earthy Minerals and Mining.

A TREATISE ON EARTHY & OTHER MINERALS AND MINING. By D. C. DAVIES, F.G.S., Author of "Metalliferous Minerals," &c. Third Edition, revised and Enlarged, by his Son, E. HENRY DAVIES, M.E., F.G.S. With about 100 Illustrations. Crown 8vo, 12s. 6d. cloth.

"We do not remember to have met with any English work on mining matters that contains the same amount of information packed in equally convenient form."—*Academy*.

"We should be inclined to rank it as among the very best of the handy technical and trades manuals which have recently appeared."—*British Quarterly Review*.

Metalliferous Mining in the United Kingdom.

BRITISH MINING: A Treatise on the History, Discovery, Practical Development, and Future Prospects of Metalliferous Mines in the United Kingdom. By ROBERT HUNT, F.R.S., Editor of "Ure's Dictionary of Arts, Manufactures, and Mines," &c. Upwards of 950 pp., with 430 Illustrations. Second Edition, Revised. Super-royal 8vo, £2 2s. cloth.

"One of the most valuable works of reference of modern times. Mr. Hunt, as Keeper of Mining Records of the United Kingdom, has had opportunities for such a task not enjoyed by anyone else and has evidently made the most of them. . . . The language and style adopted are good, and the treatment of the various subjects laborious, conscientious, and scientific."—*Engineering*.

"The book is, in fact, a treasure-house of statistical information on mining subjects, and we know of no other work embodying so great a mass of matter of this kind. Were this the only merit of Mr. Hunt's volume, it would be sufficient to render it indispensable in the library of everyone interested in the development of the mining and metallurgical industries of this country."—*Athenæum*.

"A mass of information not elsewhere available, and of the greatest value to those who may be interested in our great mineral industries."—*Engineer*.

Underground Pumping Machinery.

MINE DRAINAGE. Being a Complete and Practical Treatise on Direct-Acting Underground Steam Pumping Machinery, with a Description of a large number of the best known Engines, their General Utility and the Special Sphere of their Action, the Mode of their Application, and their merits compared with other forms of Pumping Machinery. By STEPHEN MICHELL. 8vo, 15s. cloth.

"Will be highly esteemed by colliery owners and lessees, mining engineers, and students generally who require to be acquainted with the best means of securing the drainage of mines. It is a most valuable work, and stands almost alone in the literature of steam pumping machinery."—*Colliery Guardian*.

"Much valuable information is given, so that the book is thoroughly worthy of an extensive circulation amongst practical men and purchasers of machinery."—*Mining Journal*.

Prospecting for Gold and other Metals.

THE PROSPECTOR'S HANDBOOK: A Guide for the Prospector and Traveller in Search of Metal-Bearing or other Valuable Minerals. By J. W. ANDERSON, M.A. (Camb.), F.R.G.S., Author of "Fiji and New Caledonia." Fifth Edition, thoroughly Revised and Enlarged. Small crown 8vo, 3s. 6d. cloth.

"Will supply a much felt want, especially among Colonists, in whose way are so often thrown many mineralogical specimens the value of which it is difficult to determine."—*Engineer*.

"How to find commercial minerals, and how to identify them when they are found, are the leading points to which attention is directed. The author has managed to pack as much practical detail into his pages as would supply material for a book three times its size."—*Mining Journal*.

Mining Notes and Formulæ.

NOTES AND FORMULÆ FOR MINING STUDENTS. By JOHN HERMAN MERIVALE, M.A., Certificated Colliery Manager, Professor of Mining in the Durham College of Science, Newcastle-upon-Tyne. Third Edition, Revised and Enlarged. Small crown 8vo, 2s. 6d. cloth.

"Invaluable to anyone who is working up for an examination on mining subjects."—*Iron and Coal Trades Review*.

"The author has done his work in an exceedingly creditable manner, and has produced a book that will be of service to students, and those who are practically engaged in mining operations."—*Engineer*.

Handybook for Miners.

THE MINER'S HANDBOOK: A Handy Book of Reference on the Subjects of Mineral Deposits, Mining Operations, Ore Dressing, &c. For the Use of Students and others interested in Mining matters. Compiled by JOHN MILNE, F.R.S., Professor of Mining in the Imperial University of Japan. Revised Edition. Fcap. 8vo, 7s. 6d. leather. [Just published.]

"Professor Milne's handbook is sure to be received with favour by all connected with mining, and will be extremely popular among students."—*Athenæum*.

Miners' and Metallurgists' Pocket-Book.

A POCKET-BOOK FOR MINERS AND METALLURGISTS. Comprising Rules, Formulæ, Tables, and Notes, for Use in Field and Office Work. By F. DANVERS POWER, F.G.S., M.E. Fcap. 8vo, 9s. leather, gilt edges.

"This excellent book is an admirable example of its kind, and ought to find a large sale amongst English-speaking prospectors and mining engineers."—*Engineering*.

"Miners and metallurgists will find in this work a useful *vade-mecum* containing a mass of rules, formulæ, tables, and various other information, the necessity for reference to which occurs in their daily duties."—*Iron*.

Mineral Surveying and Valuing.

THE MINERAL SURVEYOR AND VALUER'S COMPLETE GUIDE, comprising a Treatise on Improved Mining Surveying and the Valuation of Mining Properties, with New Traverse Tables. By WM. LINTERN. Third Edition, Enlarged. 12mo, 4s. cloth.

"Mr. Lintern's book forms a valuable and thoroughly trustworthy guide."—*Iron and Coal Trades Review*.

Asbestos and its Uses.

ASBESTOS: Its Properties, Occurrence, and Uses. With some Account of the Mines of Italy and Canada. By ROBERT H. JONES. With Eight Colotype Plates and other Illustrations. Crown 8vo, 12s. 6d. cloth.

"An interesting and invaluable work."—*Colliery Guardian*.

Explosives.

A HANDBOOK ON MODERN EXPLOSIVES. Being a Practical Treatise on the Manufacture and Application of Dynamite, Gun-Cotton, Nitro-Glycerine, and other Explosive Compounds. Including the Manufacture of Collodion-Cotton. By M. EISSLER, Mining Engineer and Metallurgical Chemist. Author of "The Metallurgy of Gold," "The Metallurgy of Silver," &c. With about 100 Illusts. Crown 8vo, 10s. 6d. cloth.

"Useful not only to the miner, but also to officers of both services to whom blasting and the use of explosives generally may at any time become a necessary auxiliary."—*Nature*.

"A veritable mine of information on the subject of explosives employed for military, mining and blasting purposes."—*Army and Navy Gazette*.

Colliery Management.

THE COLLIERY MANAGER'S HANDBOOK: A Comprehensive Treatise on the Laying-out and Working of Collieries. Designed as a Book of Reference for Colliery Managers, and for the Use of Coal-Mining Students preparing for First-class Certificates. By CALB PAMELY, Mining Engineer and Surveyor: Member of the North of England Institute of Mining and Mechanical Engineers; and Member of the South Wales Institute of Mining Engineers. With nearly 500 Plans, Diagrams, and other Illustrations. Second Edition, Revised, with Additions. Medium 8vo, about 700 pages. Price £1 5s. strongly bound.

SUMMARY OF CONTENTS.

GEOLOGY.—SEARCH FOR COAL.—MINERAL LEASES AND OTHER HOLDINGS.—SHAFT SINKING.—FITTING UP THE SHAFT AND SURFACE ARRANGEMENTS.—STEAM BOILERS AND THEIR FITTINGS.—TIMBERING AND WALLING.—NARROW WORK AND METHODS OF WORKING.—UNDERGROUND CONVEYANCE.—DRAINAGE.—THE GASES MET WITH IN MINES: VENTILATION.—ON THE FRICTION OF AIR IN MINES.—

THE PRIESTMAN OIL ENGINE; PETROLEUM AND NATURAL GAS.—SURVEYING AND PLANNING.—SAFETY LAMPS AND FIRE-DAMP DETECTORS.—SUNDRY AND INCIDENTAL OPERATIONS AND APPLIANCES.—COLLIERY EXPLOSIONS.—MISCELLANEOUS QUESTIONS & ANSWERS.

Appendix: SUMMARY OF REPORT OF H.M. COMMISSIONERS ON ACCIDENTS IN MINES.

* * * OPINIONS OF THE PRESS.

"Mr. Pameley has not only given us a comprehensive reference book of a very high order, suitable to the requirements of mining engineers and colliery managers, but at the same time has provided mining students with a class-book that is as interesting as it is instructive."—*Colliery Manager*.

"Mr. Pameley's work is eminently suited to the purpose for which it is intended—being clear, interesting, exhaustive, rich in detail, and up to date, giving descriptions of the very latest machines in every department. . . . A mining engineer could scarcely go wrong who followed this work."—*Colliery Guardian*.

"This is the most complete 'all round' work on coal-mining published in the English language. . . . No library of coal-mining books is complete without it."—*Colliery Engineer* (Scranton, Pa., U.S.A.).

"Mr. Pameley's work is in all respects worthy of our admiration. No person in any responsible position connected with mines should be without a copy."—*Westminster Review*.

Coal and Iron.

THE COAL AND IRON INDUSTRIES OF THE UNITED KINGDOM. Comprising a Description of the Coal Fields, and of the Principal Seams of Coal, with Returns of their Produce and its Distribution, and Analyses of Special Varieties. Also an Account of the occurrence of Iron Ores in Veins or Seams; Analyses of each Variety; and a History of the Rise and Progress of Pig Iron Manufacture. By RICHARD MEADE, Assistant Keeper of Mining Records. With Maps. 8vo, £1 8s. cloth.

"The book is one which must find a place on the shelves of all interested in coal and iron production, and in the iron, steel, and other metallurgical industries."—*Engineer*.

"Of this book we may unreservedly say that it is the best of its class which we have ever met. . . . A book of reference which no one engaged in the iron or coal trades should omit from his library."—*Iron and Coal Trades Review*.

Coal Mining.

COAL AND COAL MINING: A Rudimentary Treatise on. By the late Sir WARINGTON W. SMYTH, M.A., F.R.S., &c., Chief Inspector of the Mines of the Crown. Seventh Edition, Revised and Enlarged. With numerous Illustrations. 12mo, 4s. cloth boards.

"As an outline is given of every known coal-field in this and other countries, as well as of the principal methods of working, the book will doubtless interest a very large number of readers."—*Mining Journal*.

Subterranean Surveying.

SUBTERRANEAN SURVEYING, Elementary and Practical Treatise on, with and without the Magnetic Needle. By THOMAS FENWICK, Surveyor of Mines, and THOMAS BAKER, C.E. Illust. 12mo, 3s. cloth boards.

Granite Quarrying.

GRANITES AND OUR GRANITE INDUSTRIES. By GEORGE F. HARRIS, F.G.S., Membre de la Société Belge de Géologie, Lecturer on Economic Geology at the Birkbeck Institution, &c. With Illustrations. Crown 8vo, 2s. 6d. cloth.

"A clearly and well-written manual on the granite industry."—*Scotsman*.

"An interesting work, which will be deservedly esteemed."—*Colliery Guardian*.

"An exceedingly interesting and valuable monograph on a subject which has hitherto received an accountably little attention in the shape of systematic literary treatment."—*Scottish Leader*.

Gold, Metallurgy of.

THE METALLURGY OF GOLD: A Practical Treatise on the Metallurgical Treatment of Gold-bearing Ores. Including the Processes of Concentration and Chlorination, and the Assaying, Melting, and Refining of Gold. By M. EISSLER, Mining Engineer and Metallurgical Chemist, formerly Assistant Assayer of the U. S. Mint, San Francisco. Third Edition, Revised and greatly Enlarged. With 187 Illustrations. Crown 8vo, 12s. 6d. cloth.

"This book thoroughly deserves its title of a 'Practical Treatise.' The whole process of gold mining, from the breaking of the quartz to the assay of the bullion, is described in clear and orderly narrative and with much, but not too much, fulness of detail."—*Saturday Review*.

"The work is a storehouse of information and valuable data, and we strongly recommend it to all professional men engaged in the gold-mining industry."—*Mining Journal*.

Silver, Metallurgy of.

THE METALLURGY OF SILVER: A Practical Treatise on the Amalgamation, Roasting, and Lixivation of Silver Ores. Including the Assaying, Melting and Refining, of Silver Bullion. By M. EISSLER, Author of "The Metallurgy of Gold," &c. Second Edition, Enlarged. With 150 Illustrations. Crown 8vo, 10s. 6d. cloth.

"A practical treatise, and a technical work which we are convinced will supply a long-felt want amongst practical men, and at the same time be of value to students and others indirectly connected with the industries."—*Mining Journal*.

"From first to last the book is thoroughly sound and reliable."—*Colliery Guardian*.

"For chemists, practical miners, assayers, and investors alike, we do not know of any work on the subject so handy and yet so comprehensive."—*Glasgow Herald*.

Lead, Metallurgy of.

THE METALLURGY OF ARGENTIFEROUS LEAD: A Practical Treatise on the Smelting of Silver-Lead Ores and the Refining of Lead Bullion. Including Reports on various Smelting Establishments and Descriptions of Modern Smelting Furnaces and Plants in Europe and America. By M. EISSLER, M.E., Author of "The Metallurgy of Gold," &c. Crown 8vo, 400 pp., with 183 Illustrations, 12s. 6d. cloth.

"The numerous metallurgical processes, which are fully and extensively treated of, embrace all the stages experienced in the passage of the lead from the various natural states to its issue from the refinery as an article of commerce."—*Practical Engineer*.

"The present volume fully maintains the reputation of the author. Those who wish to obtain a thorough insight into the present state of this industry cannot do better than read this volume, and all mining engineers cannot fail to find many useful hints and suggestions in it."—*Industries*.

"It is most carefully written and illustrated with capital drawings and diagrams. In fact, it is the work of an expert for experts, by whom it will be prized as an indispensable text-book."—*Bristol Mercury*.

Iron, Metallurgy of.

METALLURGY OF IRON. Containing History of Iron Manufacture, Methods of Assay, and Analyses of Iron Ores, Processes of Manufacture of Iron and Steel, &c. By H. BAUERMAN, F.G.S., A.R.S.M. With numerous Illustrations. Sixth Edition, Revised and Enlarged. 12mo, 5s. 6d. cloth.

"Carefully written, it has the merit of brevity and conciseness, as to less important points, while all material matters are very fully and thoroughly entered into."—*Standard*.

Iron Mining.

THE IRON ORES OF GREAT BRITAIN AND IRELAND: Their Mode of Occurrence, Age, and Origin, and the Methods of Searching for and Working them, with a Notice of some of the Iron Ores of Spain. By J. D. KENDALL, F.G.S., Mining Engineer. With Plates and Illustrations. Crown 8vo, 16s. cloth.

"The author has a thorough practical knowledge of his subject, and has supplemented a careful study of the available literature by unpublished information derived from his own observations. The result is a very useful volume which cannot fail to be of value to all interested in the iron industry of the country."—*Industries*.

"Constitutes a systematic and careful account of our present knowledge of the origin and occurrence of the iron ores of Great Britain, and embraces a description of the means employed in reaching and working these ores."—*Iron*.

"Mr. Kendall is a great authority on this subject and writes from personal observation."—*Colliery Guardian*.

"Mr. Kendall's book is thoroughly well done. In it there are the outlines of the history of ore mining in every centre and there is everything that we want to know as to the character of the ores of each district, their commercial value and the cost of working them."—*Iron and Steel Trades Journal*.

ELECTRICITY, ELECTRICAL ENGINEERING, etc.

Electrical Engineering.

THE ELECTRICAL ENGINEER'S POCKET-BOOK OF MODERN RULES, FORMULÆ, TABLES, AND DATA. By H. R. KEMPE, M.Inst.E.E., A.M.Inst.C.E., Technical Officer, Postal Telegraphs, Author of "A Handbook of Electrical Testing," &c. Second Edition, thoroughly Revised, with Additions. With numerous Illustrations. Royal 32mo, oblong, 5s. leather.

"There is very little in the shape of formulæ or data which the electrician is likely to want in a hurry which cannot be found in its pages."—*Practical Engineer*.

"A very useful book of reference for daily use in practical electrical engineering and its various applications to the industries of the present day."—*Iron*.

"It is the best book of its kind."—*Electrical Engineer*.

"Well arranged and compact. The 'Electrical Engineer's Pocket-Book' is a good one."—*Electrician*.

"Strongly recommended to those engaged in the various electrical industries."—*Electrician Review*.

Electric Lighting.

ELECTRIC LIGHT FITTING: A Handbook for Working Electrical Engineers, embodying Practical Notes on Installation Management. By JOHN W. URQUHART, Electrician, Author of "Electric Light," &c. With numerous Illustrations. Second Edition, Revised, with Additional Chapters. Crown 8vo, 5s. cloth.

"This volume deals with what may be termed the mechanics of electric lighting, and is addressed to men who are already engaged in the work or are training for it. The work traverses a great deal of ground, and may be read as a sequel to the same author's useful work on 'Electric Light.'"—*Electrician*.

"This is an attempt to state in the simplest language the precautions which should be adopted in installing the electric light, and to give information, for the guidance of those who have to run the plant when installed. The book is well worth the perusal of the workmen for whom it is written."—*Electrical Review*.

"We have read this book with a good deal of pleasure. We believe that the book will be of use to practical workmen, who will not be alarmed by finding mathematical formulæ which they are unable to understand."—*Electrical Plant*.

"Eminently practical and useful. . . . Ought to be in the hands of everyone in charge of an electric light plant."—*Electrical Engineer*.

"Mr. Urquhart has succeeded in producing a really capital book, which we have no hesitation in recommending to the notice of working electricians and electrical engineers."—*Mechanical World*.

Electric Light.

ELECTRIC LIGHT: Its Production and Use. Embodying Plain Directions for the Treatment of Dynamo-Electric Machines, Batteries, Accumulators, and Electric Lamps. By J. W. URQUHART, C.E., Author of "Electric Light Fitting," "Electroplating," &c. Fifth Edition, carefully Revised, with Large Additions and 145 Illustrations. Crown 8vo, 7s. 6d. cloth.

"The whole ground of electric lighting is more or less covered and explained in a very clear and concise manner."—*Electrical Review*.

"Contains a good deal of very interesting information, especially in the parts where the author gives dimensions and working costs."—*Electrical Engineer*.

"A miniature *vade-mecum* of the salient facts connected with the science of electric lighting."—*Electrician*.

"You cannot for your purpose have a better book than 'Electric Light,' by Urquhart."—*Engineer*.

"The book is by far the best that we have yet met with on the subject."—*Athenæum*.

Construction of Dynamos.

DYNAMO CONSTRUCTION: A Practical Handbook for the Use of Engineer Constructors and Electricians-in-Charge. Embracing Framework Building, Field Magnet and Armature Winding and Grouping, Compounding, &c. With Examples of leading English, American, and Continental Dynamos and Motors. By J. W. URQUHART, Author of "Electric Light," "Electric Light Fitting," &c. With upwards of 100 Illustrations. Crown 8vo, 7s. 6d. cloth.

"Mr. Urquhart's book is the first one which deals with these matters in such a way that the engineering student can understand them. The book is very readable, and the author leads his readers up to difficult subjects by reasonably simple tests."—*Engineering Review*.

"The author deals with his subject in a style so popular as to make his volume a handbook of great practical value to engineer constructors and electricians in charge of lighting installations."—*Scottman*.

"'Dynamo Construction' more than sustains the high character of the author's previous publications. It is sure to be widely read by the large and rapidly-increasing number of practical electricians."—*Glasgow Herald*.

"A book for which a demand has long existed."—*Mechanical World*.

A New Dictionary of Electricity.

THE STANDARD ELECTRICAL DICTIONARY. A Popular Dictionary of Words and Terms Used in the Practice of Electrical Engineering. Containing upwards of 3,000 Definitions. By T. O'CONNOR SLOANE A.M., Ph.D., Author of "The Arithmetic of Electricity," &c. Crown 8vo, 650 pp., 350 Illustrations, 7s. 6d. cloth. *[Just published.]*

"The work has many attractive features in it, and is beyond doubt, a well put together and useful publication. The amount of ground covered may be gathered from the fact that in the index about 5,000 references will be found. The inclusion of such comparatively modern words as 'impedence,' 'reluctance,' &c., shows that the author has desired to be up to date, and indeed there are other indications of carefulness of compilation. The work is one which does the author great credit and it should prove of great value, especially to students."—*Electrical Review.*

"We have found the book very complete and reliable, and can, therefore, commend it heartily."—*Mechanical World.*

"Very complete and contains a large amount of useful information."—*Industries.*

"An encyclopedia of electrical science in the compass of a dictionary. The information given is sound and clear. The book is well printed, well illustrated, and well up to date, and may be confidently recommended."—*Builder.*

"We hail the appearance of this little work as one which will meet a want that has been keenly felt for some time. The author is to be congratulated on the excellent manner in which he has accomplished his task."—*Practical Engineer.*

"The volume is excellently printed and illustrated, and should form part of the library every one who is directly or indirectly connected with electrical matters."—*Hardware Trade Journal.*

Electric Lighting of Ships.

ELECTRIC SHIP-LIGHTING: A Handbook on the Practical Fitting and Running of Ship's Electrical Plant. For the Use of Shipowners and Builders, Marine Electricians, and Sea-going Engineers-in-Charge. By J. W. URQUHART, C.E., Author of "Electric Light," &c. With 88 Illustrations. Crown 8vo, 7s. 6d. cloth.

"The subject of ship electric lighting is one of vast importance in these days, and Mr. Urquhart is to be highly complimented for placing such a valuable work at the service of the practical marine electrician."—*The Steamship.*

"Distinctly a book which of its kind stands almost alone, and for which there should be a demand."—*Electrical Review.*

Electric Lighting.

THE ELEMENTARY PRINCIPLES OF ELECTRIC LIGHTING. By ALAN A. CAMPBELL SWINTON, Associate I.E.E. Third Edition, Enlarged and Revised. With 16 Illustrations. Crown 8vo, 1s. 6d. cloth.

"Anyone who desires a short and thoroughly clear exposition of the elementary principles of electric lighting cannot do better than read this little work."—*Bradford Observer.*

Dynamic Electricity.

THE ELEMENTS OF DYNAMIC ELECTRICITY AND MAGNETISM. By PHILIP ATKINSON, A.M., Ph.D., Author of "Elements of Static Electricity," "The Elements of Electric Lighting," &c. &c. Crown 8vo, 417 pp., with 120 Illustrations, 10s. 6d. cloth.

Electric Motors, &c.

THE ELECTRIC TRANSFORMATION OF POWER and its Application by the Electric Motor, including Electric Railway Construction. By P. ATKINSON, A.M., Ph.D., Author of "The Elements of Electric Lighting," &c. With 96 Illustrations. Crown 8vo, 7s. 6d. cloth.

Dynamo Construction.

HOW TO MAKE A DYNAMO: A Practical Treatise for Amateurs Containing numerous Illustrations and Detailed Instructions for Constructing a Small Dynamo, to Produce the Electric Light. By ALFRED CROFTS. Fourth Edition, Revised and Enlarged. Crown 8vo, 2s. cloth.

"The instructions given in this unpretentious little book are sufficiently clear and explicit to enable any amateur mechanic possessed of average skill and the usual tools to be found in an amateur's workshop, to build a practical dynamo machine."—*Electrician.*

Text Book of Electricity.

THE STUDENT'S TEXT-BOOK OF ELECTRICITY. By HENRY M. NOAD, Ph.D., F.R.S. New Edition, carefully Revised. With Introduction and Additional Chapters, by W. H. FREECE, M.I.C.E. Crown 8vo, 12s. 6d. cloth.

Electricity.

A MANUAL OF ELECTRICITY: Including Galvanism, Magnetism, Dia-Magnetism, Electro-Dynamics. By HENRY M. NOAD Ph.D., F.R.S. Fourth Edition (1859). 8vo £1 4s. cloth.

ARCHITECTURE, BUILDING, etc.**Building Construction.**

PRACTICAL BUILDING CONSTRUCTION: A Handbook for Students Preparing for Examinations, and a Book of Reference for Persons Engaged in Building. By JOHN PARNELL ALLEN, Surveyor, Lecturer on Building Construction at the Durham College of Science, Newcastle-on-Tyne. Medium 8vo, 450 pages, with 1,000 Illustrations. 12s. 6d. cloth. [Just published.]

"This volume is one of the most complete expositions of building construction we have seen. It contains all that is necessary to prepare students for the various examinations in building construction."—*Building News*.

"The author depends nearly as much on his diagrams as on his type. The pages suggest the hand of a man of experience in building operations—and the volume must be a blessing to many teachers as well as to students."—*The Architect*.

"This volume promises to be the recognised handbook in all advanced classes where building construction is taught from a practical point of view. We strongly commend the book to the notice of all teachers of building construction."—*Technical World*.

"The work is sure to prove a formidable rival to great and small competitors alike, and bids fair to take a permanent place as a favourite students' text-book. The large number of illustrations deserve particular mention for the great merit they possess for purposes of reference, in exactly corresponding to convenient scales."—*Four. Inst. Brit. Archts.*

Concrete.

CONCRETE: ITS NATURE AND USES. A Book for Architects, Builders, Contractors, and Clerks of Works. By GEORGE L. SUTCLIFFE, A.R.I.B.A. 350 pages, with numerous illustrations. Crown 8vo, 7s. 6d. cloth. [Just published.]

"The author treats a difficult subject in a lucid manner. The manual fills a long-felt gap. It is careful and exhaustive; equally useful as a student's guide and a architect's book of reference."—*Journal of Royal Institution of British Architects*.

"There is room for this new book, which will probably be for some time the standard work on the subject for a builder's purpose."—*Glasgow Herald*.

"A thoroughly useful and comprehensive work."—*British Architect*.

Mechanics for Architects.

THE MECHANICS OF ARCHITECTURE: A Treatise on Applied Mechanics, especially Adapted to the Use of Architects. By E. W. TARN, M.A., Author of "The Science of Building," &c. Second Edition, Enlarged. Illust. with 125 Diagrams. Cr. 8vo, 7s. 6d. cloth. [Just published.]

"The book is a very useful and helpful manual of architectural mechanics, and really contains sufficient to enable a careful and painstaking student to grasp the principles bearing upon the majority of building problems. . . . Mr. Tarn has added, by this volume, to the debt of gratitude which is owing to him by architectural students for the many valuable works which he has produced for their use."—*The Builder*.

"The mechanics in the volume are really mechanics, and are harmoniously wrought in with the distinctive professional manner proper to the subject. The diagrams and type are commendably clear."—*The Schoolmaster*.

The New Builder's Price Book, 1894.

LOCKWOOD'S BUILDER'S PRICE BOOK FOR 1894. A Comprehensive Handbook of the Latest Prices and Data for Builders, Architects, Engineers, and Contractors. Re-constructed, Re-written, and Greatly Enlarged. By FRANCIS T. W. MILLER. 700 closely-printed pages, crown 8vo, 4s. cloth.

"This book is a very useful one, and should find a place in every English office connected with the building and engineering professions."—*Industries*.

"An excellent book of reference."—*Architect*.

"In its new and revised form this Price Book what a work of this kind should be—comprehensive, reliable, well arranged, legible, and well bound."—*British Architect*.

Designing Buildings.

THE DESIGN OF BUILDINGS: Being Elementary Notes on the Planning, Sanitation and Ornamentive Formation of Structures, based on Modern Practice. Illustrated with Nine Folding Plates. By W. WOOLLEY, Assistant Master, Metropolitan Drawing Classes, &c. Demy 8vo, 6s. cloth. [Just published.]

Sir Wm. Chambers's Treatise on Civil Architecture.

THE DECORATIVE PART OF CIVIL ARCHITECTURE.

By Sir WILLIAM CHAMBERS, F.R.S. With Portrait, Illustrations, Notes, and an Examination of Grecian Architecture, by JOSEPH GWILT, F.S.A. Revised and Edited by W. H. LEEDS. 66 Plates, 4to, 21s. cloth.

Villa Architecture.

A HANDY BOOK OF VILLA ARCHITECTURE: *Being a Series of Designs for Villa Residences in various Styles.* With Outline Specifications and Estimates. By C. WICKES, Architect, Author of "The Spires and Towers of England," &c. 61 Plates. 4to, £1 11s. 6d. half-morocco. "The whole of the designs bear evidence of their being the work of an artistic architect, and they will prove very valuable and suggestive."—*Building News*.

Text-Book for Architects.

THE ARCHITECT'S GUIDE: *Being a Text-Book of Useful Information for Architects, Engineers, Surveyors, Contractors, Clerks of Works, &c. &c.* By FREDERICK ROGERS, Architect. Third Edition. Crown 8vo, 3s. 6d. cloth.

"As a text-book of useful information for architects, engineers, surveyors, &c., it would be hard to find a handier or more complete little volume."—*Standard*.

Taylor and Cresy's Rome.

THE ARCHITECTURAL ANTIQUITIES OF ROME. By the late G. L. TAYLOR, Esq., F.R.I.B.A., and EDWARD CRESY, Esq., New Edition, thoroughly Revised by the Rev. ALEXANDER TAYLOR, M.A. (son of the late G. L. Taylor, Esq.), Fellow of Queen's College, Oxford, and Chaplain of Gray's Inn. Large folio, with 13c Plates. £3 3s. half-bound.

"Taylor and Cresy's work has from its first publication been ranked among those professional books which cannot be bettered."—*Architect*.

Linear Perspective.

ARCHITECTURAL PERSPECTIVE: The whole Course and Operations of the Draughtsman in Drawing a Large House in Linear Perspective. Illustrated by 39 Folding Plates. By F. O. FERGUSON. 8vo, 3s. 6d. boards.

"It is the most intelligible of the treatises on this ill-treated subject that I have met with."—E. INGRESS BELL, Esq., in the *R.I.B.A. Journal*.

Architectural Drawing.

PRACTICAL RULES ON DRAWING, for the Operative Builder and Young Student in Architecture. By GEORGE PYNK. With 14 Plates, 4to, 7s. 6d. boards.

Vitruvius' Architecture.

THE ARCHITECTURE of MARCUS VITRUVIUS POLLIO. Translated by JOSEPH GWILT, F.S.A., F.R.A.S. New Edition, Revised by the Translator. With 23 Plates. Fcap. 8vo, 5s. cloth.

Designing, Measuring, and Valuing.

THE STUDENT'S GUIDE to the PRACTICE of MEASURING AND VALUING ARTIFICERS' WORK. Containing Directions for taking Dimensions, Abstracting the same, and bringing the Quantities into Bill, with Tables of Constants for Valuation of Labour, and for the Calculation of Areas and Solidities, Originally edited by EDWARD DOBSON, Architect. With Additions by E. WYNDHAM TARN, M.A. Sixth Edition. With 8 Plates and 63 Woodcuts. Crown 8vo, 7s. 6d. cloth.

"This edition will be found the most complete treatise on the principles of measuring and valuing artificers' work that has yet been published."—*Building News*.

Pocket Estimator and Technical Guide.

THE POCKET TECHNICAL GUIDE, MEASURER, AND ESTIMATOR FOR BUILDERS AND SURVEYORS. Containing Technical Directions for Measuring Work in all the Building Trades, Complete Specifications for Houses, Roads, and Drains, and an easy Method of Estimating the parts of a Building collectively. By A. C. BEATON. Sixth Edit. Waistcoat-pocket size, 1s. 6d. leather, gilt edges.

"No builder, architect, surveyor, or valuer should be without his 'Beaton.'"—*Building News*.

Donaldson on Specifications.

THE HANDBOOK OF SPECIFICATIONS; or, Practical Guide to the Architect, Engineer, Surveyor, and Builder, in drawing up Specifications and Contracts for Works and Constructions. Illustrated by Precedents of Buildings actually executed by eminent Architects and Engineers. By Professor T. L. DONALDSON, F.R.I.B.A., &c. New Edition. 8vo, with upwards of 1,000 pages of Text, and 33 Plates. £1 11s. 6d. cloth.

"Valuable as a record, and more valuable still as a book of precedents. Suffice it to say that Donaldson's 'Handbook of Specifications' must be bought by all architects."—*Builder*.

Bartholomew and Rogers' Specifications.**SPECIFICATIONS FOR PRACTICAL ARCHITECTURE.**

A Guide to the Architect, Engineer, Surveyor, and Builder. With an Essay on the Structure and Science of Modern Buildings. Upon the Basis of the Work by ALFRED BARTHOLOMEW, thoroughly Revised, Corrected, and greatly added to by FREDERICK ROGERS, Architect. Third Edition, Revised, with Additions. With numerous Illustrations. Medium 8vo, 155. cloth.

"The collection of specifications prepared by Mr. Rogers on the basis of Bartholomew's work is too well known to need any recommendation from us. It is one of the books with which every young architect must be equipped."—*Architect*.

Construction.

THE SCIENCE OF BUILDING: An Elementary Treatise on the Principles of Construction. By E. WYNDHAM TARN, M.A., Architect. Third Edition, Revised and Enlarged. With 59 Engravings. Fcap. 8vo, 45. cl.

"A very valuable book, which we strongly recommend to all students."—*Builder*.

House Building and Repairing.

THE HOUSE-OWNER'S ESTIMATOR: or, What will it Cost to Build, Alter, or Repair? A Price Book for Unprofessional People, as well as the Architectural Surveyor and Builder. By J. D. SIMON. Edited by F. T. W. MILLER, A.R.I.B.A. Fourth Edition. Crown 8vo, 35. 6d. cloth.

"In two years it will repay its cost a hundred times over."—*Field*.

Cottages and Villas.

COUNTRY AND SUBURBAN COTTAGES AND VILLAS: How to Plan and Build Them. Containing 33 Plates, with Introduction, General Explanations, and Description of each Plate. By JAMES W. BOGUE, Architect, Author of "Domestic Architecture," &c. 4to, 105. 6d. cloth.

Building; Civil and Ecclesiastical.

A BOOK ON BUILDING, Civil and Ecclesiastical, including Church Restoration; with the Theory of Domes and the Great Pyramid, &c. By Sir EDMUND BECKETT, Bart., LL.D., F.R.A.S. Second Edition. Fcap. 8vo, 55. cloth.

"A book which is always amusing and nearly always instructive."—*Times*.

Sanitary Houses, etc.

THE SANITARY ARRANGEMENT OF DWELLING-HOUSES: A Handbook for Householders and Owners of Houses. By A. J. WALLIS-TAYLER, A.M. Inst. C.E. With numerous Illustrations. Crown 8vo, 25. 6d. cloth. [Just published.]

Ventilation of Buildings.

VENTILATION. A Text Book to the Practice of the Art of Ventilating Buildings. By W. P. BUCHAN, R.P. 12mo, 45. cloth.

"Contains a great amount of useful practical information, as thoroughly interesting as it is technically reliable."—*British Architect*.

The Art of Plumbing.

PLUMBING. A Text Book to the Practice of the Art or Craft of the Plumber. By WILLIAM FATON BUCHAN, R.P. Sixth Edition, Enlarged. 12mo, 45. cloth.

"A text-book which may be safely put in the hands of every young plumber."—*Builder*.

Geometry for the Architect, Engineer, etc.

PRACTICAL GEOMETRY, for the Architect, Engineer, and Mechanic. Giving Rules for the Delineation and Application of various Geometrical Lines, Figures and Curves. By E. W. TARN, M.A., Architect. 8vo, 95. cloth.

"No book with the same objects in view has ever been published in which the clearness of the rules laid down and the illustrative diagrams have been so satisfactory."—*Scotsman*.

The Science of Geometry.

THE GEOMETRY OF COMPASSES; or, Problems Resolved by the mere Description of Circles, and the use of Coloured Diagrams and Symbols. By OLIVER EYRNE. Coloured Plates. Crown 8vo, 35. 6d. cloth.

CARPENTRY, TIMBER, etc.**Tredgold's Carpentry, Revised & Enlarged by Tarn.****THE ELEMENTARY PRINCIPLES OF CARPENTRY.**

A Treatise on the Pressure and Equilibrium of Timber Framing, the Resistance of Timber, and the Construction of Floors, Arches, Bridges, Roofs, Uniting Iron and Stone with Timber, &c. To which is added an Essay on the Nature and Properties of Timber, &c., with Descriptions of the kinds of Wood used in Building; also numerous Tables of the Scantlings of Timber for different purposes, the Specific Gravities of Materials, &c. By THOMAS TREDGOLD, C.E. With an Appendix of Specimens of Various Roofs of Iron and Stone, Illustrated. Seventh Edition, thoroughly revised and considerably enlarged by E. WYNDHAM TARN, M.A., Author of "The Science of Building," &c. With 61 Plates, Portrait of the Author, and several Woodcuts. In One large Vol., 4to, price £1 5s. cloth.

"Ought to be in every architect's and every builder's library."—*Builder*.

"A work whose monumental excellence must commend it wherever skillful carpentry is concerned. The author's principles are rather confirmed than impaired by time. The additional plates are of great intrinsic value."—*Building News*.

Woodworking Machinery.

WOODWORKING MACHINERY: Its Rise, Progress, and Construction. With Hints on the Management of Saw Mills and the Economical Conversion of Timber. Illustrated with Examples of Recent Designs by leading English, French, and American Engineers. By M. POWIS BALE, A.M.Inst.C.E., M.I.M.E. Second Edition, Revised, with large Additions.

Large crown 8vo, 440 pp., 9s. cloth. [Just published.]

"Mr. Bale is evidently an expert on the subject and he has collected so much information that book is all-sufficient for builders and others engaged in the conversion of timber."—*Architect*.

"The most comprehensive compendium of wood-working machinery we have seen. The author is a thorough master of his subject."—*Building News*.

Saw Mills.

SAW MILLS: Their Arrangement and Management, and the Economical Conversion of Timber. (A Companion Volume to "Woodworking Machinery.") By M. POWIS BALE. Crown 8vo, 10s. 6d. cloth.

"The administration of a large sawing establishment is discussed, and the subject examined from a financial standpoint. Hence the size, shape, order, and disposition of saw-mills and the like are gone into in detail, and the course of the timber is traced from its reception to its delivery in its converted state. We could not desire a more complete or practical treatise."—*Builder*.

Nicholson's Carpentry.

THE CARPENTER'S NEW GUIDE: or, Book of Lines for Carpenters; comprising all the Elementary Principles essential for acquiring a knowledge of Carpentry. Founded on the late PETER NICHOLSON'S Standard Work. New Edition. Revised by A. ASHPITEL, F.S.A. With Practical Rules on Drawing, by G. PYKE. With 74 Plates. 4to, £1 1s. cloth.

Handrailing and Stairbuilding.

A PRACTICAL TREATISE ON HANDRAILING: Showing New and Simple Methods for Finding the Pitch of the Plank, Drawing the Moulds, Beveling, Jointing-up, and Squaring the Wreath. By GEORGE COLLINGS. Second Edition, Revised and Enlarged, to which is added A TREATISE ON STAIRBUILDING. 12mo, 2s. 6d. cloth limp.

"Will be found of practical utility in the execution of this difficult branch of joinery."—*Builder*.

"Almost every difficult phase of this somewhat intricate branch of joinery is elucidated by the aid of plates and explanatory letterpress."—*Furniture Gazette*.

Circular Work.

CIRCULAR WORK IN CARPENTRY AND JOINERY: A Practical Treatise on Circular Work of Single and Double Curvature. By GEORGE COLLINGS. With Diagrams. Second Edit. 12mo, 2s. 6d. cloth limp.

"An excellent example of what a book of this kind should be. Cheap in price, clear in definition and practical in the examples selected."—*Builder*.

Handrailing.

HANDRAILING COMPLETE IN EIGHT LESSONS. On the Square-Cut System. By J. S. GOLDTHORP, Teacher of Geometry and Building Construction at the Halifax Mechanic's Institute. With Eight Plates and over 150 Practical Exercises. 4to, 3s. 6d. cloth.

"Likely to be of considerable value to joiners and others who take a pride in good work, we heartily commend it to teachers and students."—*Timber Trades Journal*.

Timber Merchant's Companion.

THE TIMBER MERCHANT'S AND BUILDER'S COMPANION. Containing New and Copious Tables of the Reduced Weight and Measurement of Deals and Battens, of all sizes, from One to a Thousand Pieces, and the relative Price that each size bears per Lineal Foot to any given Price per Petersburg Standard Hundred; the Price per Cube Foot of Square Timber to any given Price per Load of 50 Feet; the proportionate Value of Deals and Battens by the Standard, to Square Timber by the Load of 50 Feet; the readiest mode of ascertaining the Price of Scantling per Lineal Foot of any size, to any given Figure per Cube Foot, &c. &c. By WILLIAM DOWSING. Fourth Edition, Revised and Corrected. Cr. 8vo, 3s. cl.

"Everything is as concise and clear as it can possibly be made. There can be no doubt that every timber merchant and builder ought to possess it."—*Hull Advertiser*.

"We are glad to see a fourth edition of these admirable tables, which for correctness and simplicity of arrangement leave nothing to be desired."—*Timber Trades Journal*.

Practical Timber Merchant.

THE PRACTICAL TIMBER MERCHANT. Being a Guide for the use of Building Contractors, Surveyors, Builders, &c., comprising useful Tables for all purposes connected with the Timber Trade, Marks of Wood, Essay on the Strength of Timber, Remarks on the Growth of Timber, &c. By W. RICHARDSON. Fcap. 8vo, 3s. 6d. cloth.

"This handy manual contains much valuable information for the use of timber merchants, builders, foresters, and all others connected with the growth, sale, and manufacture of timber."—*Journal of Forestry*.

Timber Freight Book.

THE TIMBER MERCHANT'S, SAW MILLER'S, AND IMPORTER'S FREIGHT BOOK AND ASSISTANT. Comprising Rules, Tables, and Memoranda relating to the Timber Trade. By WILLIAM RICHARDSON, Timber Broker; together with a Chapter on "SPEEDS OF SAW MILL MACHINERY," by M. POWIS BALE, M.I.M.E., &c. 12mo, 3s. 6d. cl. boards.

"A very useful manual of rules, tables, and memoranda relating to the timber trade. We recommend it as a compendium of calculation to all timber measurers and merchants, and as supplying a real want in the trade."—*Building News*.

Packing-Case Makers, Tables for.

PACKING-CASE TABLES; showing the number of Superficial Feet in Boxes or Packing-Cases, from six inches square and upwards. By W. RICHARDSON, Timber Broker. Third Edition. Oblong 4to, 3s. 6d. cl.

"Invaluable labour-saving tables."—*Ironmonger*.

"Will save much labour and calculation."—*Grocer*.

Superficial Measurement.

THE TRADESMAN'S GUIDE TO SUPERFICIAL MEASUREMENT. Tables calculated from 1 to 200 inches in length, by 1 to 108 inches in breadth. For the use of Architects, Surveyors, Engineers, Timber Merchants, Builders, &c. By JAMES HAWKINS. Fourth Edition. Fcap., 3s. 6d. cloth.

"A useful collection of tables to facilitate rapid calculation of surfaces. The exact area of any surface of which the limits have been ascertained can be instantly determined. The book will be found of the greatest utility to all engaged in building operations."—*Contractor*.

"These tables will be found of great assistance to all who require to make calculations in superficial measurement."—*English Mechanic*.

Forestry.

THE ELEMENTS OF FORESTRY. Designed to afford Information concerning the Planting and Care of Forest Trees for Ornament or Profit, with Suggestions upon the Creation and Care of Woodlands. By F. B. HOUGH. Large crown 8vo, 10s. cloth.

Timber Importer's Guide.

THE TIMBER IMPORTER'S, TIMBER MERCHANT'S, AND BUILDER'S STANDARD GUIDE. By RICHARD E. GRANDY. Comprising an Analysis of Deal Standards, Home and Foreign, with Comparative Values and Tabular Arrangements for fixing Net Landed Cost on Baltic and North American Deals, including all intermediate Expenses, Freight, Insurance, &c. &c. Together with copious Information for the Retailer and Builder. Third Edition, Revised. 12mo, 2s. cloth limp.

"Everything it pretends to be: built up gradually, it leads one from a forest to a treasuriel, and throws in, as a makeweight, a host of material concerning bricks, columns, cisterns, &c."—*English Mechanic*.

DECORATIVE ARTS, etc.

Woods and Marbles (Imitation of).

SCHOOL OF PAINTING FOR THE IMITATION OF WOODS AND MARBLES, as Taught and Practised by A. R. VAN DER BURG and P. VAN DER BURG, Directors of the Rotterdam Painting Institution. Royal folio, 18½ by 12½ in., Illustrated with 24 full-size Coloured Plates; also 12 plain Plates, comprising 154 Figures. Second and Cheaper Edition. Price £1 11s. 6d.

List of Plates.

1. Various Tools required for Wood Painting—2, 3. Walnut: Preliminary Stages of Graining and Finished Specimen—4. Tools used for Marble Painting and Methods of Manipulation—5, 6. St. Remi Marble: Earlier Operations and Finished Specimen—7. Methods of Sketching different Grains, Knots, &c.—8, 9. Ash: Preliminary Stages and Finished Specimen—10. Methods of Sketching Marble Grains—11, 12. Breche Marble: Preliminary Stages of Working and Finished Specimen—13. Maple: Methods of Producing the different Grains—14, 15. Bird's-eye Maple: Preliminary Stages and Finished Specimen—16. Methods of Sketching the different Species of White Marble—17, 18. White Marble: Preliminary Stages of Process and

Finished Specimen—19. Mahogany: Specimens of various Grains and Methods of Manipulation—20, 21. Mahogany: Earlier Stages and Finished Specimen—22, 23, 24. Sienna Marble: Varieties of Grain, Preliminary Stages and Finished Specimen—25, 26, 27. Juniper Wood: Methods of producing Grain, &c.: Preliminary Stages and Finished Specimen—28, 29, 30. Vert de Mer Marble: Varieties of Grain and Methods of Working Unfinished and Finished Specimens—31, 32, 33. Oak: Varieties of Grain, Tools Employed, and Methods of Manipulation, Preliminary Stages and Finished Specimen—34, 35, 36. Wauisort Marble: Varieties of Grain, Unfinished and Finished Specimens.

"Those who desire to attain skill in the art of painting woods and marbles will find advantage in consulting this book. Some of the Working Men's Clubs should give their young men the opportunity to study it."—*Builder*.

"A comprehensive guide to the art. The explanations of the processes, the manipulation and management of the colours, and the beautifully executed plates will not be the least valuable to the student who aims at making his work a faithful transcript of nature."—*Building News*.

Wall Paper.

WALL PAPER DECORATION. By ARTHUR SEYMOUR JENNINGS, Author of "Practical Paper Hanging." With numerous Illustrations. Demy 8vo. [In preparation.]

House Decoration.

ELEMENTARY DECORATION. A Guide to the Simpler Forms of Everyday Art. Together with **PRACTICAL HOUSE DECORATION.** By JAMES W. FACEY. With numerous Illustrations. In One Vol 3s. strongly half-bound.

House Painting, Graining, etc.

HOUSE PAINTING, GRAINING, MARBLING, AND SIGN WRITING, A Practical Manual of. By ELLIS A. DAVIDSON. Sixth Edition With Coloured Plates and Wood Engravings. 12mo, 6s. cloth boards.

"A mass of information, of use to the amateur and of value to the practical man."—*English Mechanic*.

Decorators, Receipts for.

THE DECORATOR'S ASSISTANT: A Modern Guide to Decorative Artists and Amateurs, Painters, Writers, Gilders, &c. Containing upwards of 600 Receipts, Rules and Instructions; with a variety of Information for General Work connected with every Class of Interior and Exterior Decorations, &c. Fifth Edition, Revised. 152 pp., crown 8vo, 1s. in wrapper.

"Full of receipts of value to decorators, painters, gilders, &c. The book contains the gist of larger treatises on colour and technical processes. It would be difficult to meet with a work so full of varied information on the painter's art."—*Building News*.

Moyr Smith on Interior Decoration.

ORNAMENTAL INTERIORS, ANCIENT AND MODERN. By J. MOYR SMITH. Super-royal 8vo, with 32 full-page Plates and numerous smaller Illustrations, handsomely bound in cloth, gilt top, price 18s.

The book is well illustrated and handsomely got up, and contains some true criticism and a good many good examples of decorative treatment."—*The Builder*.

British and Foreign Marbles.

MARBLE DECORATION and the Terminology of British and Foreign Marbles. A Handbook for Students. By GEORGE H. BLAGROVE, Author of "Shoring and its Application," &c. With 28 Illustrations. Crown 8vo, 3s. 6d. cloth.

"This most useful and much wanted handbook should be in the hands of every architect and builder."—*Building World*.

"A carefully and usefully written treatise; the work is essentially practical."—*Scottsman*.

Marble Working, etc.

MARBLE AND MARBLE WORKERS: A Handbook for Architects, Artists, Masons, and Students. By ARTHUR LEE, Author of "A Visit to Carrara," "The Working of Marble," &c. Small crown 8vo, 2s. cloth.

"A really valuable addition to the technical literature of architects and masons."—*Building News*.

DELAMOTTE'S WORKS ON ILLUMINATION AND ALPHABETS.

A PRIMER OF THE ART OF ILLUMINATION, for the Use of Beginners: with a Rudimentary Treatise on the Art. Practical Directions for its Exercise, and Examples taken from Illuminated MSS., printed in Gold and Colours. By F. DELAMOTTE. New and Cheaper Edition. Small 4to, 6s. ornamental boards.

"The examples of ancient MSS. recommended to the student, which, with much good sense, the author chooses from collections accessible to all, are selected with judgment and knowledge, as well as taste."—*Athenaeum*.

ORNAMENTAL ALPHABETS, Ancient and Medieval, from the Eighth Century, with Numerals; including Gothic, Church-Text, large and small, German, Italian, Arabesque, Initials for Illumination, Monograms, Crosses, &c. &c., for the use of Architectural and Engineering Draughtsmen, Missal Painters, Masons, Decorative Painters, Lithographers, Engravers, Carvers, &c. &c. Collected and Engraved by F. DELAMOTTE, and printed in Colours. New and Cheaper Edition. Royal 8vo, oblong, 2s. 6d. ornamental boards.

"For those who insert enamelled sentences round gilded chalices, who blazon shop legends over shop-doors, who letter church walls with pithy sentences from the Decalogue, this book will be useful."—*Athenaeum*.

EXAMPLES OF MODERN ALPHABETS, Plain and Ornamental; including German, Old English, Saxon, Italic, Perspective, Greek, Hebrew, Court Hand, Engrossing, Tuscan, Riband, Gothic, Rustic, and Arabesque; with several Original Designs, and an Analysis of the Roman and Old English Alphabets, large and small, and Numerals, for the use of Draughtsmen, Surveyors, Masons, Decorative Painters, Lithographers, Engravers, Carvers, &c. Collected and Engraved by F. DELAMOTTE, and printed in Colours. New and Cheaper Edition. Royal 8vo, oblong, 2s. 6d. ornamental boards.

"There is comprised in it every possible shape into which the letters of the alphabet and numerals can be formed, and the talent which has been expended in the conception of the various plain and ornamental letters is wonderful."—*Standard*.

MEDIAEVAL ALPHABETS AND INITIALS FOR ILLUMINATION.

By F. G. DELAMOTTE. Containing 21 Plates and Illuminated Title, printed in Gold and Colours. With an Introduction by J. WILLIS BROOKS. Fourth and Cheaper Edition. Small 4to, 4s. ornamental boards.

"A volume in which the letters of the alphabet come forth glorified in gilding and all the colours of the prism interwoven and intertwined and intermingled."—*Sun*.

THE EMBROIDERER'S BOOK OF DESIGN. Containing Initials, Emblems, Cyphers, Monograms, Ornamental Borders, Ecclesiastical Devices, Mediaeval and Modern Alphabets, and National Emblems. Collected by F. DELAMOTTE, and printed in Colours. Oblong royal 8vo, 1s. 6d. ornamental wrapper.

The book will be of great assistance to ladies and young children who are endowed with the art of plying the needle in this most ornamental and useful pretty work."—*East Anglian Times*.

Wood Carving.

INSTRUCTIONS IN WOOD-CARVING, for Amateurs; with Hints on Design. By A LADY. With Ten Plates. New and Cheaper Edition. Crown 8vo, 2s. in emblematic wrapper.

"The handicraft of the wood-carver, so well as a book can impart it, may be learnt from 'A Lady's' publication."—*Athenaeum*.

NATURAL SCIENCE, etc.

The Heavens and their Origin.

THE VISIBLE UNIVERSE: Chapters on the Origin and Construction of the Heavens. By J. E. GORE, F.R.A.S., Author of "Star Groups," &c. Illustrated by 6 Stellar Photographs and 12 Plates. Demy 8vo, 16s. cloth, gilt top.

"A valuable and lucid summary of recent astronomical theory, rendered more valuable and attractive by a series of stellar photographs and other illustrations."—*The Times*.

"In presenting a clear and concise account of the present state of our knowledge, Mr. Gore has made a valuable addition to the literature of the subject."—*Nature*.

"One of the finest works on astronomical science that has recently appeared in our language. In spirit and in method it is scientific from cover to cover, but the style is so clear and attractive that it will be as acceptable and as readable to those who make no scientific pretensions as to those who devote themselves specially to matters astronomical."—*Leeds Mercury*.

"As interesting as a novel, and instructive without; the text being made still more luminous by stellar photographs and other illustrations. . . . A most valuable book."—*Manchester Examiner*.

The Constellations.

STAR GROUPS: A Student's Guide to the Constellations. By J. ELLARD GORE, F.R.A.S., M.R.I.A., &c., Author of "The Visible Universe,"

"The Scenery of the Heavens." With 30 Maps. Small 4to, 5s. cloth, silvered.

"A knowledge of the principal constellations visible in our latitudes may be easily acquired from the thirty maps and accompanying text contained in this work."—*Nature*.

"The volume contains thirty maps showing stars of the sixth magnitude—the usual naked-eye limit—and each is accompanied by a brief commentary, adapted to facilitate recognition and bring to notice objects of special interest. For the purpose of a preliminary survey of the 'midnight pomp of the heavens,' nothing could be better than a set of delineations averaging scarcely twenty square inches in area, and including nothing that cannot at once be identified."—*Saturday Review*.

"A very compact and handy guide to the constellations."—*Athenaeum*.

Astronomical Terms.

AN ASTRONOMICAL GLOSSARY; or, Dictionary of Terms used in Astronomy. With Tables of Data and Lists of Remarkable and Interesting Celestial Objects. By J. ELLARD GORE, F.R.A.S., Author of "The Visible Universe," &c. Small crown 8vo, 2s. 6d. cloth.

"A very useful little work for beginners in astronomy, and not to be despised by more advanced students."—*The Times*.

"A very handy book. . . . the utility of which is much increased by its valuable tables of astronomical data."—*The Athenaeum*.

"Astronomers of all kinds will be glad to have it for reference."—*Guardian*.

The Microscope.

THE MICROSCOPE: Its Construction and Management, including Technique, Photo-micrography, and the Past and Future of the Microscope. By Dr. HENRI VAN HEURCK, Director of the Antwerp Botanical Gardens. English Edition, Re-Edited and Augmented by the Author from the Fourth French Edition, and Translated by WYNNE E. BAXTER, F.R.M.S., F.G.S., &c. About 400 pages, with Three Plates and upwards of 250 Woodcuts. Imp. 8vo, 18s. cloth gilt.

"A translation of a well-known work, at once popular and comprehensive."—*Times*.

"The translation is as felicitous as it is accurate."—*Nature*.

Astronomy.

ASTRONOMY. By the late Rev. ROBERT MAIN, M.A., F.R.S. Third Edition, Revised, by WM. THYNNE LYNN, B.A., F.R.A.S., formerly of the Royal Observatory, Greenwich. 12mo, 2s. cloth limp.

"A sound and simple treatise, and a capital book for beginners."—*Knowledge*.

"Accurately brought down to the requirements of the present time."—*Educational Times*.

Recent and Fossil Shells.

A MANUAL OF THE MOLLUSCA: Being a Treatise on Recent and Fossil Shells. By S. P. WOODWARD, A.L.S., F.G.S., late Assistant Palaeontologist in the British Museum. With an Appendix on Recent and Fossil Conchological Discoveries, by RALPH TATE, A.L.S., F.G.S. Illustrated by A. N. WATERHOUSE and JOSEPH WILSON LOWRY. With 23 Plates and upwards of 300 Woodcuts. Reprint of Fourth Ed., 1880. Cr. 8vo, 7s. 6d. cl.

"A most valuable storehouse of conchological and geological information."—*Science Gossip*.

Geology and Genesis.

THE TWIN RECORDS OF CREATION; or, Geology and Genesis: their Perfect Harmony and Wonderful Concord. By GEORGE W. VICTOR LE VAUX. Fcap. 8vo, 5s. cloth.

"A valuable contribution to the evidences of Revelation, and disposes very conclusively of the arguments of those who would set God's Works against God's Word. No real difficulty is shirked and no sophistry is left unexposed."—*The Rock*.

DR. LARDNER'S COURSE OF NATURAL PHILOSOPHY.

THE HANDBOOK OF MECHANICS. Enlarged and almost Rewritten by BENJAMIN LOEWY, F.R.A.S. With 378 Illustrations. Post 8vo, 6s. cloth.

"The perspicuity of the original has been retained, and chapters which had become obsolete have been replaced by others of more modern character. The explanations throughout are studiously popular, and care has been taken to show the application of the various branches of physics to the industrial arts, and to the practical business of life."—*Mining Journal*.

"Mr. Loewy has carefully revised the book, and brought it up to modern requirements."—*Nature*.

"Natural philosophy has had few exponents more able or better skilled in the art of popularising the subject than Dr. Lardner; and Mr. Loewy is doing good service in fitting this treatise, and the others of the series, for use at the present time."—*Scottsman*.

THE HANDBOOK OF HYDROSTATICS AND PNEUMATICS.

New Edition, Revised and Enlarged, by BENJAMIN LOEWY, F.R.A.S. With 236 Illustrations. Post 8vo, 5s. cloth.

"For those who desire to attain an accurate knowledge of physical science without the profound methods of mathematical investigation, this work is not merely intended, but well adapted."—*Chemical News*.

"The volume before us has been carefully edited, augmented to nearly twice the bulk of the former edition, and all the most recent matter has been added. . . . It is a valuable text-book."—*Nature*.

"Candidates for pass examinations will find it, we think, specially suited to their requirements."—*English Mechanic*.

THE HANDBOOK OF HEAT. Edited and almost entirely Rewritten by BENJAMIN LOEWY, F.R.A.S., &c. 117 Illusts. Post 8vo, 6s. cloth.

"The style is always clear and precise, and conveys instruction without leaving any cloudiness or lurking doubts behind."—*Engineering*.

"A most exhaustive book on the subject on which it treats, and is so arranged that it can be understood by all who desire to attain an accurate knowledge of physical science. . . . Mr. Loewy has included all the latest discoveries in the varied laws and effects of heat."—*Standard*.

"A complete and handy text-book for the use of students and general readers."—*English Mechanic*.

THE HANDBOOK OF OPTICS. By DIONYSIUS LARDNER, D.C.L., formerly Professor of Natural Philosophy and Astronomy in University College, London. New Edition. Edited by T. OLIVER HARDING, B.A. Lond., of University College, London. With 298 Illustrations. Small 8vo, 448 pages, 5s. cloth.

"Written by one of the ablest English scientific writers, beautifully and elaborately illustrated."—*Mechanic's Magazine*.

THE HANDBOOK OF ELECTRICITY, MAGNETISM, AND ACOUSTICS. By Dr. LARDNER. Ninth Thousand. Edit. by GEORGE CAREY FOSTER, B.A., F.C.S. With 400 Illustrations. Small 8vo, 5s. cloth.

"The book could not have been entrusted to anyone better calculated to preserve the terse and lucid style of Lardner, while correcting his errors and bringing up his work to the present state of scientific knowledge."—*Popular Science Review*.

THE HANDBOOK OF ASTRONOMY. Forming a Companion to the "Handbook of Natural Philosophy." By DIONYSIUS LARDNER, D.C.L., formerly Professor of Natural Philosophy and Astronomy in University College, London. Fourth Edition, Revised and Edited by EDWIN DUNKIN, F.R.A.S., Royal Observatory, Greenwich. With 38 Plates and upwards of 100 Woodcuts. In One Vol., small 8vo, 550 pages, 9s. 6d. cloth.

"Probably no other book contains the same amount of information in so compendious and well-arranged a form—certainly none at the price at which this is offered to the public."—*Athenaeum*.

"We can do no other than pronounce this work a most valuable manual of astronomy, and we strongly recommend it to all who wish to acquire a general—but at the same time correct—acquaintance with this sublime science."—*Quarterly Journal of Science*.

"One of the most deservedly popular books on the subject. . . . We would recommend not only the student of the elementary principles of the science, but he who aims at mastering the higher and mathematical branches of astronomy, not to be without this work beside him."—*Practical Magazines*.

Geology.

RUDIMENTARY TREATISE ON GEOLOGY, PHYSICAL AND HISTORICAL. Consisting of "Physical Geology," which sets forth the leading Principles of the Science; and "Historical Geology," which treats of the Mineral and Organic Conditions of the Earth at each successive epoch, especial reference being made to the British Series of Rocks. By RALPH TATE, A.L.S., F.G.S., &c. With 250 Illustrations. 12mo, 5s. cl. bds.

"The fulness of the matter has elevated the book into a manual. Its information is exhaustive and well arranged."—*School Board Chronicle*.

DR. LARDNER'S MUSEUM OF SCIENCE AND ART.

THE MUSEUM OF SCIENCE AND ART. Edited by DIONYSIUS LARDNER, D.C.L., formerly Professor of Natural Philosophy and Astronomy in University College, London. With upwards of 1,200 Engravings on Wood. In 6 Double Volumes, £1 1s. in a new and elegant cloth binding; or handsomely bound in half-morocco, 31s. 6d.

. OPINIONS OF THE PRESS.

"This series, besides affording popular but sound instruction on scientific subjects, with which the humblest man in the country ought to be acquainted, also undertakes, that teaching of 'Common Things' which every well-wisher of his kind is anxious to promote. Many thousand copies of this serviceable publication have been printed, in the belief and hope that the desire for instruction and improvement widely prevails; and we have no fear that such enlightened faith will meet with disappointment."—*Times*.

"A cheap and interesting publication, alike informing and attractive. The papers combine subjects of importance and great scientific knowledge, considerable inductive powers, and a popular style of treatment."—*Spectator*.

"The 'Museum of Science and Art' is the most valuable contribution that has ever been made to the Scientific Instruction of every class of society."—Sir DAVID BREWSTER, in the *North British Review*.

"Whether we consider the liberality and beauty of the illustrations, the charm of the writing, or the durable interest of the matter, we must express our belief that there is hardly to be found among the new books one that would be welcomed by people of so many ages and classes as a valuable present."—*Examiner*.

. Separate books formed from the above, suitable for Workmen's Libraries, Science Classes, &c.

Common Things Explained. Containing Air, Earth, Fire, Water, Time, Man, the Eye, Locomotion, Colour, Clocks and Watches, &c. 233 Illustrations, cloth gilt, 5s.

The Microscope. Containing Optical Images, Magnifying Glasses, Origin and Description of the Microscope, Microscopic Objects, the Solar Microscope, Microscopic Drawing and Engraving, &c. 147 Illustrations, cloth gilt, 2s.

Popular Geology. Containing Earthquakes and Volcanoes, the Crust of the Earth, &c. 201 Illustrations, cloth gilt, 2s. 6d.

Popular Physics. Containing Magnitude and Minuteness, the Atmosphere, Meteoric Stones, Popular Fallacies, Weather Prognostics, the Thermometer, the Barometer, Sound, &c. 85 Illustrations, cloth gilt, 2s. 6d.

Steam and its Uses. Including the Steam Engine, the Locomotive, and Steam Navigation. 89 Illustrations, cloth gilt, 2s.

Popular Astronomy. Containing How to observe the Heavens—The Earth, Sun, Moon, Planets, Light, Comets, Eclipses, Astronomical Influences, &c. 182 Illustrations, cloth gilt, 4s. 6d.

The Bee and White Ants: Their Manners and Habits. With Illustrations of Animal Instinct and Intelligence. 135 Illustrations, cloth gilt, 2s.

The Electric Telegraph Popularized. To render intelligible to all who can Read, irrespective of any previous Scientific Acquirements, the various forms of Telegraphy in Actual Operation. 100 Illustrations, cloth gilt, 1s. 6d.

Dr. Lardner's School Handbooks.

NATURAL PHILOSOPHY FOR SCHOOLS. By Dr. LARDNER. 328 Illustrations. Sixth Edition. One Vol., 3s. 6d. cloth.

"A very convenient class-book for junior students in private schools. It is intended to convey in clear and precise terms, general notions of all the principal divisions of Physical Science."—*British Quarterly Review*.

ANIMAL PHYSIOLOGY FOR SCHOOLS. By Dr. LARDNER. With 190 Illustrations. Second Edition. One Vol., 3s. 6d. cloth.

"Clearly written, well arranged, and excellently illustrated."—*Gardener's Chronicle*.

Lardner and Bright on the Electric Telegraph.

THE ELECTRIC TELEGRAPH. By Dr. LARDNER. Revised and Re-written by E. B. BRIGHT, F.R.A.S. 140 Illustrations. Small 8vo, 2s. 6d. cloth.

"One of the most readable books extant on the Electric Telegraph."—*English Mechanic*.

CHEMICAL MANUFACTURES, CHEMISTRY.

Chemistry for Engineers, etc.

ENGINEERING CHEMISTRY: A Practical Treatise for the Use of Analytical Chemists, Engineers, Iron Masters, Iron Founders, Students, and others. Comprising Methods of Analysis and Valuation of the Principal Materials used in Engineering Work, with numerous Analyses, Examples, and Suggestions. By H. JOSHUA PHILLIPS, F.I.C., F.C.S. formerly Analytical and Consulting Chemist to the Great Eastern Railway. Second Edition, Revised and Enlarged. Crown 8vo, 400 pp., with Illustrations, ros. 6d. cloth. [Just published.]

"In this work the author has rendered no small service to a numerous body of practical men. . . . The analytical methods may be pronounced most satisfactory, being as accurate as the despatch required of engineering chemists permits."—*Chemical News*.

"Those in search of a handy treatise on the subject of analytical chemistry as applied to the every-day requirements of workshop practice will find this volume of great assistance."—*Iron*.

"The first attempt to bring forward a Chemistry specially written for the use of engineers, and we have no hesitation whatever in saying that it should at once be in the possession of every railway engineer."—*The Railway Engineer*.

"The book will be very useful to those who require a handy and concise resume of approved methods of analysing and valuing metals, oils, fuels, &c. It is, in fact, a work for chemists, a guide to the routine of the engineering laboratory. . . . The book is full of good things. As a handbook of technical analysis, it is very welcome."—*Builder*.

"Considering the extensive ground which such a subject as Engineering Chemistry covers, the work is complete, and recommends itself to both the practising analyst and the analytical student."—*Chemical Trade Journal*.

"The analytical methods given are, as a whole, such as are likely to give rapid and trustworthy results in experienced hands. There is much excellent descriptive matter in the work, the chapter on 'Oils and Lubrication' being specially noticeable in this respect."—*Engineer*.

Alkali Trade, Manufacture of Sulphuric Acid, etc.

A MANUAL OF THE ALKALI TRADE, including the Manufacture of Sulphuric Acid, Sulphate of Soda, and Bleaching Powder. By JOHN LOMAS, Alkali Manufacturer, Newcastle-upon-Tyne and London. With 323 Illustrations and Working Drawings, and containing 390 pages of Text. Second Edition, with Additions. Super-royal 8vo, £1 ros. cloth.

"This book is written by a manufacturer for manufacturers. The working details of the most approved forms of apparatus are given, and these are accompanied by no less than 323 wood engravings, all of which may be used for the purposes of construction. Every step in the manufacture is very fully described in this manual, and each improvement explained."—*Athenæum*.

"We find not merely a sound and luminous explanation of the chemical principles of the trade, but a notice of numerous matters which have a most important bearing on the successful conduct of alkali works, but which are generally overlooked by even experienced technological authors."—*Chemical Review*.

The Blowpipe.

THE BLOWPIPE IN CHEMISTRY, MINERALOGY, AND GEOLOGY. Containing all known Methods of Anhydrous Analysis, many Working Examples, and Instructions for Making Apparatus. By Lieut.-Colonel W. A. ROSS, R.A., F.G.S. With 120 Illustrations. Second Edition, Revised and Enlarged. Crown 8vo, 5s. cloth.

"The student who goes through the course of experimentation here laid down will gain a better insight into inorganic chemistry and mineralogy than if he had 'got up' any of the best text-books, and passed any number of examinations in their contents."—*Chemical News*.

Commercial Chemical Analysis.

THE COMMERCIAL HANDBOOK OF CHEMICAL ANALYSIS; or, Practical Instructions for the determination of the Intrinsic or Commercial Value of Substances used in Manufactures, in Trades, and in the Arts. By A. NORMANDY, Editor of Rose's "Treatise on Chemical Analysis." New Edition, to a great extent Re-written by HENRY M. NODD, Ph.D., F.R.S. With numerous illustrations. Crown 8vo, 7s. 6d. cloth.

"We strongly recommend this book to our readers as a guide, alike indispensable to the housewife as to the pharmaceutical practitioner."—*Medical Times*.

"Essential to the analysts appointed under the new Act. The most recent results are given and the work is well edited and carefully written."—*Nature*.

Dye-Wares and Colours.

THE MANUAL OF COLOURS AND DYE-WARES: Their Properties, Applications, Valuations, Impurities, and Sophistications. For the use of Dyers, Printers, Drysalterers, Brokers, &c. By J. W. SLATER. Second Edition, Revised and greatly Enlarged. Crown 8vo, 7s. 6d. cloth.

"A complete encyclopædia of the *materia tinctoria*. The information given respecting each article is full and precise, and the methods of determining the value of articles such as these, so liable to sophistication, are given with clearness, and are practical as well as valuable."—*Chemist and Druggist*.

"There is no other work which covers precisely the same ground. To students preparing for examinations in dyeing and printing it will prove exceedingly useful."—*Chemical News*.

Modern Brewing and Malting.

A HANDYBOOK FOR BREWERS: Being a Practical Guide to the Art of Brewing and Malting. Embracing the Conclusions of Modern Research which bear upon the Practice of Brewing. By HERBERT EDWARDS WRIGHT, M.A. Crown 8vo, 530 pp., 12s. 6d. cloth.

"May be consulted with advantage by the student who is preparing himself for examinational tests, while the scientific brewer will find in it a *resumé* of all the most important discoveries of modern times. The work is written throughout in a clear and concise manner, and the author takes great care to discriminate between vague theories and well-established facts."—*Brewers' Journal*.

"We have great pleasure in recommending this handybook, and have no hesitation in saying that it is one of the best—if not the best—which has yet been written on the subject of beer-brewing in this country, and it should have a place on the shelves of every brewer's library."—*The Brewer's Guardian*.

"Although the requirements of the student are primarily considered, an acquaintance of half-an-hour's duration cannot fail to impress the practical brewer with the sense of having found a trustworthy guide and practical counsellor in brewery matters."—*Chemical Trade Journal*.

Analysis and Valuation of Fuels.

FUELS: SOLID, LIQUID, AND GASEOUS, Their Analysis and Valuation. For the Use of Chemists and Engineers. By H. J. PHILLIPS, F.C.S., formerly Analytical and Consulting Chemist to the Great Eastern Railway. Second Edition, Revised and Enlarged. Crown 8vo, 5s. cloth.

"Ought to have its place in the laboratory of every metallurgical establishment, and wherever fuel is used on a large scale."—*Chemical News*.

"Cannot fail to be of wide interest, especially at the present time."—*Railway News*.

Pigments.

THE ARTIST'S MANUAL OF PIGMENTS. Showing their Composition, Conditions of Permanency, Non-Permanency, and Adulterations; Effects in Combination with Each Other and with Vehicles; and the most Reliable Tests of Purity. Together with the Science and Art Department's Examination Questions on Painting. By H. C. STANDAGE. Second Edition. Crown 8vo, 2s. 6d. cloth.

"This work is indeed *multum in parvo*, and we can, with good conscience, recommend it to all who come in contact with pigments, whether as makers, dealers or users."—*Chemical Review*.

Gauging. Tables and Rules for Revenue Officers, Brewers, &c.

A POCKET BOOK OF MENSURATION AND GAUGING: Containing Tables, Rules and Memoranda for Revenue Officers, Brewers, Spirit Merchants, &c. By J. B. MANT (Inland Revenue). Second Edition, Revised. 18mo, 4s. leather.

"This handy and useful book is adapted to the requirements of the Inland Revenue Department, and will be a favourite book of reference."—*Civilian*.

"Should be in the hands of every practical brewer."—*Brewers' Journal*.

INDUSTRIAL ARTS, TRADES, AND MANUFACTURES.**Cotton Spinning.**

COTTON MANUFACTURE: A Manual of Practical Instruction in the Processes of Opening, Carding, Combing, Drawing, Doubling and Spinning of Cotton, and the Methods of Dyeing and Preparing Goods for the Market. For the Use of Operatives, Overlookers and Manufacturers. By JOHN LISTER, Technical Instructor, Pendleton. With numerous Illustrations. 8vo, 7s. 6d. cloth. [Just published.]

Flour Manufacture, Milling, &c.

FLOUR MANUFACTURE: A Treatise on Milling Science and Practice. By FRIEDRICH KICK, Imperial Regierungsrath, Professor of Mechanical Technology in the Imperial German Polytechnic Institute, Prague. Translated from the Second Enlarged and Revised Edition with Supplement. By H. H. P. POWLES, Assoc. Memb. Institution of Civil Engineers. Nearly 400 pp. Illustrated with 28 Folding Plates, and 167 Woodcuts. Royal 8vo, 25s. cloth.

"This valuable work is, and will remain, the standard authority on the science of milling. . . . The miller who has read and digested this work will have laid the foundation, so to speak, of a successful career; he will have acquired a number of general principles which he can proceed to apply. In this handsome volume we at last have the accepted text-book of modern milling in good, sound English, which has little, if any, trace of the German idiom."—*The Miller*.

"The appearance of this celebrated work in English is very opportune, and British millers will, we are sure, not be slow in availing themselves of its pages."—*Millers' Gazette*.

Agglutinants.

CEMENTS, PASTES, GLUES AND GUMS: A Practical Guide to the Manufacture and Application of the various Agglutinants required in the Building, Metal-Working, Wood-Working and Leather-Working Trades, and for Workshop, Laboratory or Office Use. With upwards of 900 Recipes and Formulæ. By H. C. STANDAGE, Chemist. Crown 8vo, 2s. 6d. cloth.

"We have pleasure in speaking favourably of this volume. So far as we have had experience, which is not inconsiderable, this manual is trustworthy."—*Athenæum*.

"As a revelation of what are considered trade secrets, this book will arouse an amount of curiosity among the large number of industries it touches."—*Daily Chronicle*.

"In this goodly collection of receipts it would be strange if a cement for any purpose cannot be found."—*Oil and Colourman's Journal*.

Soap-making.

THE ART OF SOAP-MAKING: A Practical Handbook of the Manufacture of Hard and Soft Soaps, Toilet Soaps, etc. Including many New Processes, and a Chapter on the Recovery of Glycerine from Waste Lays. By ALEXANDER WATT, Fourth Edition, Enlarged. Crown 8vo, 7s. 6d. cloth.

"The work will prove very useful, not merely to the technological student, but to the practical soap-boiler who wishes to understand the theory of his art."—*Chemical News*.

"A thoroughly practical treatise on an art which has almost no literature in our language. We congratulate the author on the success of his endeavour to fill a void in English technical literature."—*Nature*.

Paper Making.

PRACTICAL PAPER-MAKING: A Manual for Paper-makers and Owners and Managers of Paper-Mills. With Tables, Calculations, &c. By G. CLAPPERTON, Paper-maker. With Illustrations of Fibres from Micro-Photographs. Crown 8vo, 5s. cloth.

"The author caters for the requirements of responsible mill hands, apprentices, &c., whilst his manual will be found of great service to students of technology, as well as to veteran paper makers and mill owners. The illustrations form an excellent feature."—*Paper Trade Review*.

"We recommend everybody interested in the trade to get a copy of this thoroughly practical book."—*Paper Making*.

Paper Making.

THE ART OF PAPER MAKING: A Practical Handbook of the Manufacture of Paper from Rags, Esparto, Straw, and other Fibrous Materials, Including the Manufacture of Pulp from Wood Fibre, with a Description of the Machinery and Appliances used. To which are added Details of Processes for Recovering Soda from Waste Liquors. By ALEXANDER WATT, Author of "The Art of Soap-Making" With Illusts. Crown 8vo, 7s. 6d. cloth.

"It may be regarded as the standard work on the subject. The book is full of valuable information. The 'Art of Paper-making' is in every respect a model of a text-book, either for a technical class or for the private student."—*Paper and Printing Trades Journal*.

Leather Manufacture.

THE ART OF LEATHER MANUFACTURE. Being a Practical Handbook, in which the Operations of Tanning, Currying, and Leather Dressing are fully Described, and the Principles of Tanning Explained, and many Recent Processes Introduced; as also the Methods for the Estimation of Tannin, and a Description of the Arts of Glue Boiling, Gut Dressing, &c. By ALEXANDER WATT, Author of "Soap-Making," &c. Second Edition. Crown 8vo, 9s. cloth.

"A sound, comprehensive treatise on tanning and its accessories. It is an eminently valuable production, which redounds to the credit of both author and publishers."—*Chemical Review*.

Boot and Shoe Making.

THE ART OF BOOT AND SHOE-MAKING. A Practical Handbook, including Measurement, Last-Fitting, Cutting-Out, Closing, and Making, with a Description of the most approved Machinery employed. By JOHN B. LENO, late Editor of *St. Crispin*, and *The Boot and Shoe-Maker*. 12mo, 2s. cloth limp.

"This excellent treatise is by far the best work ever written. The chapter on clicking, which shows how waste may be prevented, will save fifty times the price of the book."

Scottish Leather Trader.

Dentistry Construction.

MECHANICAL DENTISTRY: A Practical Treatise on the Construction of the various kinds of Artificial Dentures. Comprising also Useful Formulæ, Tables, and Receipts for Gold Plate, Clasps, Solders, &c. &c. By CHARLES HUNTER. Third Edition. Crown 8vo, 3s. 6d. cloth.

"We can strongly recommend Mr. Hunter's treatise to all students preparing for the profession of dentistry as well as to every mechanical dentist."—*Dublin Journal of Medical Science*.

Wood Engraving.

WOOD ENGRAVING: A Practical and Easy Introduction to the Study of the Art. By WILLIAM NORMAN BROWN. Second Edition. With numerous Illustrations. 12mo, 1s. 6d. cloth limp.

"The book is clear and complete, and will be useful to anyone wanting to understand the first elements of the beautiful art of wood engraving."—*Graphic*.

Horology.

A TREATISE ON MODERN HOROLOGY, in Theory and Practice. Translated from the French of CLAUDIUS SAUNIER, ex-Director of the School of Horology at Maçon, by JULIEN TRIPPLIN, F.R.A.S., Besançon Watch Manufacturer, and EDWARD RIGG, M.A., Assayer in the Royal Mint. With 78 Woodcuts and 22 Coloured Copper Plates. Second Edition. Super-royal 8vo, £2 2s. cloth; £2 10s. half-cloth.

"There is no horological work in the English language at all to be compared to this production of M. Saunier's for clearness and completeness. It is alike good as a guide for the student and as a reference for the experienced horologist and skilled workman."—*Horological Journal*.

"The latest, the most complete, and the most reliable of those literary productions to which continental watchmakers are indebted for the mechanical superiority over their English brethren—in fact, the Book of Books, is M. Saunier's 'Treatise.'"—*Watchmaker, Jeweller and Silversmith*.

Watchmaking.

THE WATCHMAKER'S HANDBOOK. Intended as a Workshop Companion for those engaged in Watchmaking and the Allied Mechanical Arts. Translated from the French of CLAUDIUS SAUNIER, and considerably enlarged by JULIEN TRIPPLIN, F.R.A.S., Vice-President of the Horological Institute, and EDWARD RIGG, M.A., Assayer in the Royal Mint. With numerous Woodcuts and 14 Copper Plates. Third Edition. Crown 8vo, 9s. cloth.

"Each part is truly a treatise in itself. The arrangement is good and the language is clear and concise. It is an admirable guide for the young watchmaker."—*Engineering*.

"It is impossible to speak too highly of its excellence. It fulfils every requirement in a handbook intended for the use of a workman. Should be found in every workshop."—*Watch and Clockmaker*.

"This book contains an immense number of practical details bearing on the daily occupation of a watchmaker."—*Watchmaker and Metalworker* (Chicago).

Watches and Timekeepers.

A HISTORY OF WATCHES AND OTHER TIMEKEEPERS.

By JAMES F. KENDAL, M.B.H.Inst. 1s. 6d. boards; or 2s. 6d. cloth gilt.

"Mr. Kendal's book, for its size, is the best which has yet appeared on this subject in the English language."—*Industries*.

"Open the book where you may, there is interesting matter in it concerning the ingenious devices of the ancient or modern horologist. The subject is treated in a liberal and entertaining spirit, as might be expected of a historian who is a master of the craft."—*Saturday Review*.

Electrolysis of Gold, Silver, Copper, etc.

ELECTRO-DEPOSITION: A Practical Treatise on the Electrolysis of Gold, Silver, Copper, Nickel, and other Metals and Alloys. With descriptions of Voltaic Batteries, Magneto and Dynamo-Electric Machines, Thermopiles, and of the Materials and Processes used in every Department of the Art, and several Chapters on Electro-Metallurgy. By ALEXANDER WATT, Author of "Electro-Metallurgy," &c. Third Edition, Revised. Crown 8vo, 9s. cloth.

"Eminently a book for the practical worker in electro-deposition. It contains practical descriptions of methods, processes and materials as actually pursued and used in the workshop."—*Engineer*.

Electro-Metallurgy.

ELECTRO-METALLURGY: Practically Treated. By ALEXANDER WATT, Author of "Electro-Deposition," &c. Ninth Edition, including the most recent Processes. 12mo, 4s. cloth boards.

"From this book both amateur and artisan may learn everything necessary for the successful prosecution of electroplating."—*Iron*.

Working in Gold.

THE JEWELLER'S ASSISTANT IN THE ART OF WORKING IN GOLD: A Practical Treatise for Masters and Workmen, Compiled from the Experience of Thirty Years' Workshop Practice. By GEORGE E. GEE, Author of "The Goldsmith's Handbook," &c. Cr. 8vo, 7s. 6d. cloth.

"This manual of technical education is apparently destined to be a valuable auxiliary to a handicraft which is certainly capable of great improvement."—*The Times*.

"Very useful in the workshop, as the knowledge is practical, having been acquired by long experience, and all the recipes and directions are guaranteed to be successful."—*Jeweller and Metalworker*.

Electroplating.

ELECTROPLATING: A Practical Handbook on the Deposition of Copper, Silver, Nickel, Gold, Aluminium, Brass, Platinum, &c. &c. With Descriptions of the Chemicals, Materials, Batteries, and Dynamo Machines used in the Art. By J. W. URQUHART, C.E., Author of "Electric Light," &c. Third Edition, Revised, with Additions. Numerous Illustrations. Crown 8vo, 5s. cloth.

"An excellent practical manual."—*Engineering*.

"An excellent work, giving the newest information."—*Horological Journal*.

Electrotyping.

ELECTROTYPING: The Reproduction and Multiplication of Printing Surfaces and Works of Art by the Electro-deposition of Metals. By J. W. URQUHART, C.E. Crown 8vo, 5s. cloth.

"The book is thoroughly practical. The reader is, therefore, conducted through the leading laws of electricity, then through the metals used by electrotypers, the apparatus, and the depositing processes, up to the final preparation of the work."—*Art Journal*.

Goldsmiths' Work.

THE GOLDSMITH'S HANDBOOK. By GEORGE E. GEE, Jeweller, &c. Third Edition, considerably Enlarged. 12mo, 3s. 6d. cl. bds.

"A good, sound educator, and will be generally accepted as an authority."—*Horological Journal*.

Silversmiths' Work.

THE SILVERSMITH'S HANDBOOK. By GEORGE E. GEE, Jeweller, &c. Second Edition, Revised, with numerous Illustrations. 12mo, 3s. 6d. cloth boards.

"The chief merit of the work is its practical character. . . . The workers in the trade will speedily discover its merits when they sit down to study it."—*English Mechanic*.

*. The above two works together, strongly half-bound, price 7s.

Bread and Biscuit Baking.

THE BREAD AND BISCUIT BAKER'S AND SUGAR-BOILER'S ASSISTANT. Including a large variety of Modern Recipes, With Remarks on the Art of Bread-making. By ROBERT WELLS, Practical Baker. Second Edition, with Additional Recipes. Crown 8vo, 2s. cloth.

"A large number of wrinkles for the ordinary cook, as well as the baker."—*Saturday Review*.

Confectionery for Hotels and Restaurants.

THE PASTRYCOOK AND CONFECTIONER'S GUIDE. For Hotels, Restaurants and the Trade in general, adapted also for Family Use. By ROBERT WELLS, Author of "The Bread and Biscuit Baker's and Sugar-Boiler's Assistant." Crown 8vo, 2s. cloth.

"We cannot speak too highly of this really excellent work. In these days of keen competition our readers cannot do better than purchase this book."—*Bakers' Times*.

Ornamental Confectionery.

ORNAMENTAL CONFECTIONERY: A Guide for Bakers, Confectioners and Pastrycooks; including a variety of Modern Recipes, and Remarks on Decorative and Coloured Work. With 129 Original Designs. By ROBERT WELLS, Practical Baker, Author of "The Bread and Biscuit Baker's and Sugar-Boiler's Assistant," &c. Crown 8vo, cloth gilt, 5s.

"A valuable work, practical, and should be in the hands of every baker and confectioner. The illustrative designs are alone worth treble the amount charged for the whole work."—*Bakers' Times*.

Flour Confectionery.

THE MODERN FLOUR CONFECTIONER. Wholesale and Retail. Containing a large Collection of Recipes for Cheap Cakes, Biscuits, &c. With Remarks on the Ingredients used in their Manufacture. To which are added Recipes for Dainties for the Working Man's Table. By R. WELLS, Author of "The Bread and Biscuit Baker," &c. Crown 8vo, 2s. cl.

"The work is of a decidedly practical character, and in every recipe regard is had to economical working."—*North British Daily Mail*.

Laundry Work.

LAUNDRY MANAGEMENT. A Handbook for Use in Private and Public Laundries, Including Descriptive Accounts of Modern Machinery and Appliances for Laundry Work. By the Editor of "The Laundry Journal." With numerous Illustrations. Second Edition. Crown 8vo, 2s. 6d. cloth.

"This book should certainly occupy an honoured place on the shelves of all housekeepers who wish to keep themselves au courant of the newest appliances and methods."—*The Queen*.

HANDYBOOKS FOR HANDICRAFTS.

By PAUL N. HASLACK,

EDITOR OF "WORK" (NEW SERIES); AUTHOR OF "LATHEWORK," "MILLING MACHINES," &c.

Crown 8vo, 144 pages, cloth, price 1s. each.

THESE HANDYBOOKS have been written to supply information for WORKMEN, STUDENTS, and AMATEURS in the several Handicrafts, on the actual PRACTICE of the WORKSHOP, and are intended to convey in plain language TECHNICAL KNOWLEDGE of the several CRAFTS. In describing the processes employed, and the manipulation of material, workshop terms are used; workshop practice is fully explained; and the text is freely illustrated with drawings of modern tools, appliances, and processes.

THE METAL TURNER'S HANDYBOOK. *A Practical Manual for Workers at the Foot-Lathe.* With over 100 Illustrations. Price 1s.

"The book will be of service alike to the amateur and the artisan turner. It displays thorough knowledge of the subject."—*Sotsman*.

THE WOOD TURNER'S HANDYBOOK. *A Practical Manual for Workers at the Lathe.* With over 100 Illustrations. Price 1s.

"We recommend the book to young turners and amateurs. A multitude of workmen have hitherto sought in vain for a manual of this special industry."—*Mechanical World*.

THE WATCH JOBBER'S HANDYBOOK. *A Practical Manual on Cleaning, Repairing, and Adjusting.* With upwards of 100 Illustrations. Price 1s.

"We strongly advise all young persons connected with the watch trade to acquire and study this inexpensive work."—*Clerkenwell Chronicle*.

THE PATTERN MAKER'S HANDYBOOK. *A Practical Manual on the Construction of Patterns for Founders.* With upwards of 100 Illustrations. Price 1s.

"A most valuable, if not indispensable, manual for the pattern maker."—*Knowledge*.

THE MECHANIC'S WORKSHOP HANDYBOOK. *A Practical Manual on Mechanical Manipulation.* Embracing Information on various Handicraft Processes, with Useful Notes and Miscellaneous Memoranda. Comprising about 200 Subjects. Price 1s.

"A very clever and useful book, which should be found in every workshop; and it should certainly find a place in all technical schools."—*Saturday Review*.

THE MODEL ENGINEER'S HANDYBOOK. *A Practical Manual on the Construction of Model Steam Engines.* With upwards of 100 Illustrations. Price 1s.

"Mr. Hasluck has produced a very good little book."—*Builder*.

THE CLOCK JOBBER'S HANDYBOOK. *A Practical Manual on Cleaning, Repairing, and Adjusting.* With upwards of 100 Illustrations. Price 1s.

"It is of inestimable service to those commencing the trade."—*Coventry Standard*.

THE CABINET WORKER'S HANDYBOOK: *A Practical Manual on the Tools, Materials, Appliances, and Processes employed in Cabinet Work.* With upwards of 100 Illustrations. Price 1s.

"Mr. Hasluck's thoroughgoing little Handybook is amongst the most practical guides we have seen for beginners in cabinet-work."—*Saturday Review*.

THE WOODWORKER'S HANDYBOOK OF MANUAL INSTRUCTION. Embracing Information on the Tools, Materials, Appliances and Processes employed in Woodworking. With 104 Illustrations. Price 1s.

[Just published.]

THE METALWORKER'S HANDYBOOK. With upwards of 100 Illustrations. [In preparation.]

** OPINIONS OF THE PRESS.

"Written by a man who knows, not only how work ought to be done, but how to do it, and how to convey his knowledge to others."—*Engineering*.

"Mr. Hasluck writes admirably, and gives complete instructions."—*Engineer*.

"Mr. Hasluck combines the experience of a practical teacher with the manipulative skill and scientific knowledge of processes of the trained mechanician, and the manuals are marvels of what can be produced at a popular price."—*Schoolmaster*.

"Helpful to workmen of all ages and degrees of experience."—*Daily Chronicle*.

"Practical, sensible, and remarkably cheap."—*Journal of Education*.

"Concise, clear and practical."—*Saturday Review*.

COMMERCE, COUNTING-HOUSE WORK, TABLES, etc.

Commercial Education.

LESSONS IN COMMERCE. By Professor R. GAMBARO, of the Royal High Commercial School at Genoa. Edited and Revised by JAMES GAULT, Professor of Commerce and Commercial Law in King's College, London. Crown 8vo, 3s. 6d. cloth.

"The publishers of this work have rendered considerable service to the cause of commercial education by the opportune production of this volume. . . . The work is peculiarly acceptable to English readers and an admirable addition to existing class-books. In a phrase, we think the work attains its object in furnishing a brief account of those laws and customs of British trade with which the commercial man interested therein should be familiar."—*Chamber of Commerce Journal*.

"An invaluable guide in the hands of those who are preparing for a commercial career."—*Counting House*.

Foreign Commercial Correspondence.

THE FOREIGN COMMERCIAL CORRESPONDENT: Being Aids to Commercial Correspondence in Five Languages—English, French, German, Italian, and Spanish. By CONRAD E. BAKER. Second Edition. Crown 8vo, 3s. 6d. cloth.

"Whoever wishes to correspond in all the languages mentioned by Mr. Baker cannot do better than study this work, the materials of which are excellent and conveniently arranged. They consist not of entire specimen letters, but—what are far more useful—short passages, sentences, or phrases expressing the same general idea in various forms."—*Athenaeum*.

"A careful examination has convinced us that it is unusually complete, well arranged, and reliable. The book is a thoroughly good one."—*Schoolmaster*.

Accounts for Manufacturers.

FACTORY ACCOUNTS: Their Principles and Practice. A Handbook for Accountants and Manufacturers, with Appendices on the Nomenclature of Machine Details; the Income Tax Acts; the Rating of Factories; Fire and Boiler Insurance; the Factory and Workshop Acts, &c., including also a Glossary of Terms and a large number of Specimen Rulings. By EMIL GARCKE and J. M. FELLE. Fourth Edition, Revised and Enlarged. Demy 8vo, 250 pages, 6s. strongly bound.

"A very interesting description of the requirements of Factory Accounts. . . . the principle of assimilating the Factory Accounts to the general commercial books is one which we thoroughly agree with."—*Accountants' Journal*.

"Characterised by extreme thoroughness. There are few owners of factories who would not derive great benefit from the perusal of this most admirable work."—*Local Government Chronicle*.

Intuitive Calculations.

THE COMPENDIOUS CALCULATOR; or, Easy and Concise Methods of Performing the various Arithmetical Operations required in Commercial and Business Transactions, together with Useful Tables. By DANIEL O'GORMAN. Corrected and Extended by Professor J. R. YOUNG. Twenty-seventh Edition, Revised by C. NORRIS. Fcap. 8vo, 2s. 6d. cloth limp; or, 3s. 6d. strongly half-bound in leather.

"It would be difficult to exaggerate the usefulness of a book like this to everyone engaged in commerce or manufacturing industry. It is crammed full of rules and formulae for shortening and employing calculations."—*Knowledge*.

Modern Metrical Units and Systems.

MODERN METROLOGY: A Manual of the Metrical Units and Systems of the Present Century. With an Appendix containing a proposed English System. By LOWIS D'A. JACKSON, A.M. Inst. C.E., Author of "Aid to Survey Practice," &c. Large crown 8vo, 12s. 6d. cloth.

"We recommend the work to all interested in the practical reform of our weights and measures."—*Nature*.

The Metric System and the British Standards.

A SERIES OF METRIC TABLES, in which the British Standard Measures and Weights are compared with those of the Metric System at present in Use on the Continent. By C. H. DOWLING, C.E. 8vo, 10s. 6d. strongly bound.

"Mr. Dowling's Tables are well put together as a ready-reckoner for the conversion of one system into the other."—*Athenaeum*.

Iron and Metal Trades' Calculator.

THE IRON AND METAL TRADES' COMPANION. For expeditiously ascertaining the Value of any Goods bought or sold by Weight, from 1s. per cwt. to 112s. per cwt., and from one farthing per pound to one shilling per pound. By THOMAS DOWNIE. 396 pp., 9s. leather.

"A most useful set of tables; nothing like them before existed."—*Building News*.

"Although specially adapted to the iron and metal trades, the tables will be found useful in every other business in which merchandise is bought and sold by weight."—*Railway News*.

Chadwick's Calculator for Numbers and Weights Combined.

THE NUMBER, WEIGHT, AND FRACTIONAL CALCULATOR. Containing upwards of 250,000 Separate Calculations, showing at a glance the value at 422 different rates, ranging from $\frac{1}{12}$ th of a Penny to 20s. each, or per cwt., and £20 per ton, of any number of articles consecutively, from 1 to 470.—Any number of cwts., qrs., and lbs., from 1 cwt. to 470 cwts.—Any number of tons, cwts., qrs., and lbs., from 1 to 1,000 tons. By WILLIAM CHADWICK, Public Accountant. Third Edition, Revised and Improved. 8vo, 18s., strongly bound for Office wear and tear.

Is adapted for the use of Accountants and Auditors, Railway Companies, Canal Companies, Shippers, Shipping Agents, General Carriers, etc. Ironfounders, Brassfounders, Metal Merchants, Iron Manufacturers, Ironmongers, Engineers, Machinists, Boiler Makers, Millwrights, Roofing, Bridge and Girder Makers, Colliery Proprietors, etc. Timber Merchants, Builders, Contractors, Architects, Surveyors, Auctioneers, Valuers, Brokers, Mill Owners and Manufacturers, Mill Furnishers, Merchants, and General Wholesale Tradesmen. Also for the Apportionment of Mileage Charges for Railway Traffic.

***** OPINIONS OF THE PRESS.**

"It is as easy of reference for any answer or any number of answers as a dictionary, and the references are even more quickly made. For making up accounts or estimates the book must prove invaluable to all who have any considerable quantity of calculations involving price and measure in any combination to do."—*Engineer*.

"The most complete and practical ready reckoner which it has been our fortune yet to see. It is difficult to imagine a trade or occupation in which it could not be of the greatest use, either in saving human labour or in checking work. The publishers have placed within the reach of every commercial man an invaluable and unfailing assistant."—*The Miller*.

"The most perfect work of the kind yet prepared."—*Glasgow Herald*.

Harben's Comprehensive Weight Calculator.

THE WEIGHT CALCULATOR. Being a Series of Tables upon a New and Comprehensive Plan, exhibiting at One Reference the exact Value of any Weight from 1 lb. to 15 tons, at 300 Progressive Rates, from 1d. to 168s. per cwt., and containing 186,000 Direct Answers, which, with their Combinations, consisting of a single addition (mostly to be performed at sight), will afford an aggregate of 10,266,000 Answers; the whole being calculated and designed to ensure correctness and promote despatch. By HENRY HARBEN, Accountant. Fourth Edition, carefully Corrected. Royal 8vo, £1 5s. half-bound.

"A practical and useful work of reference for men of business generally; it is the best of the kind we have seen."—*Ironmonger*.

"Of priceless value to business men. It is a necessary book in all mercantile offices."—*Sheffield Independent*.

Harben's Comprehensive Discount Guide.

THE DISCOUNT GUIDE. Comprising several Series of Tables for the use of Merchants, Manufacturers, Ironmongers, and others, by which may be ascertained the exact Profit arising from any mode of using Discounts, either in the Purchase or Sale of Goods, and the method of either Altering a Rate of Discount or Advancing a Price, so as to produce, by one operation, a sum that will realise any required profit after allowing one or more Discounts: to which are added Tables of Profit or Advance from $\frac{1}{2}$ to 90 per cent., Tables of Discount from $\frac{1}{2}$ to 98½ per cent., and Tables of Commission, &c., from $\frac{1}{2}$ to 10 per cent. By HENRY HARBEN, Accountant, Author of "The Weight Calculator." New Edition, carefully Revised and Corrected. Demy 8vo, 544 pp., £1 5s. half-bound.

"A book such as this can only be appreciated by business men, to whom the saving of time means saving of money. We have the high authority of Professor J. R. Young that the tables throughout the work are constructed upon strictly accurate principles. The work is a model of typographical clearness, and must prove of great value to merchants, manufacturers, and general traders."—*British Trade Journal*.

Iron Shipbuilders' and Merchants' Weight Tables.

IRON-PLATE WEIGHT TABLES: For Iron Shipbuilders, Engineers, and Iron Merchants. Containing the Calculated Weights of upwards of 150,000 different sizes of Iron Plates, from 1 foot by 6 in. by $\frac{1}{2}$ in. to 10 feet by 5 feet by 1 in. Worked out on the basis of 40 lbs. to the square foot of iron of 1 inch in thickness. Carefully compiled and thoroughly Revised by H. BURLINSON and W. H. SIMPSON. Oblong 4to, 25s. half-bound.

"This work will be found of great utility. The authors have had much practical experience of what is wanting in making estimates; and the use of the book will save much time in making elaborate calculations."—*English Mechanic*.

AGRICULTURE, FARMING, GARDENING, etc.

Dr. Fream's New Edition of "The Standard Treatise on Agriculture."

THE COMPLETE GRAZIER, and FARMER'S and CATTLE-BREEDER'S ASSISTANT: A Compendium of Husbandry. Originally Written by WILLIAM YOUATT. Thirteenth Edition, entirely Re-written, considerably Enlarged, and brought up to the Present Requirements of Agricultural Practice, by WILLIAM FREAM, LL.D., Steven Lecturer in the University of Edinburgh, Author of "The Elements of Agriculture," &c. Royal 8vo, 1,100 pp., with over 450 Illustrations. £1 11s. 6d. strongly and handsomely bound.

EXTRACT FROM PUBLISHERS' ADVERTISEMENT.

"A treatise that made its original appearance in the first decade of the century, and that enters upon its Thirteenth Edition before the century has run its course, has undoubtedly established its position as a work of permanent value. . . The phenomenal progress of the last dozen years in the Practice and Science of Farming has rendered it necessary, however, that the volume should be re-written. . . and for this undertaking the publishers were fortunate enough to secure the services of Dr. FREAM, whose high attainments in all matters pertaining to agriculture have been so emphatically recognised by the highest professional and official authorities. In carrying out his editorial duties, Dr. FREAM has been favoured with valuable contributions by Prof. J. WORTLEY AXE, Mr. E. BROWN, Dr. BERNARD DYER, Mr. W. J. MALDEN, Mr. R. H. REW, Prof. SHELTON, Mr. J. SINCLAIR, Mr. SANDERS SPENCER, and others.

"As regards the illustrations of the work, no pains have been spared to make them as representative and characteristic as possible, so as to be practically useful to the Farmer and Grazier."

SUMMARY OF CONTENTS.

BOOK I. ON THE VARIETIES, BREEDING, REARING, FATTENING, AND MANAGEMENT OF CATTLE.

BOOK II. ON THE ECONOMY AND MANAGEMENT OF THE DAIRY.

BOOK III. ON THE BREEDING, REARING, AND MANAGEMENT OF HORSES.

BOOK IV. ON THE BREEDING, REARING, AND FATTENING OF SHEEP.

BOOK V. ON THE BREEDING, REARING, AND FATTENING OF SWINE.

BOOK VI. ON THE DISEASES OF LIVE STOCK.

BOOK VII. ON THE BREEDING, REARING, AND MANAGEMENT OF POULTRY.

BOOK VIII. ON FARM OFFICES AND IMPLEMENTS OF HUSBANDRY.

BOOK IX. ON THE CULTURE AND MANAGEMENT OF GRASS LANDS.

BOOK X. ON THE CULTIVATION AND APPLICATION OF GRASSES, PULSE, AND ROOTS.

BOOK XI. ON MANURES AND THEIR APPLICATION TO GRASS LAND & CROPS.

BOOK XII. MONTHLY CALENDARS OF FARMWORK.

** OPINIONS OF THE PRESS ON THE NEW EDITION.

"Dr. Fream is to be congratulated on the successful attempt he has made to give us a work which will at once become the standard classic of the farm practice of the country. We believe that it will be found that it has no compeer among the many works at present in existence. . . The illustrations are admirable, while the frontispiece, which represents the well-known bull, New Year's Gift, bred by the Queen, is a work of art."—*The Times*.

"The book must be recognised as occupying the proud position of the most exhaustive work of reference in the English language on the subject with which it deals."—*Athenaeum*.

"The most comprehensive guide to modern farm practice that exists in the English language to-day. . . The book is one that ought to be on every farm and in the library of every landowner."—*Mark Lane Express*.

"In point of exhaustiveness and accuracy the work will certainly hold a pre-eminent and unique position among books dealing with scientific agricultural practice. It is, in fact, an agricultural library of itself."—*North British Agriculturist*.

"A compendium of authoritative and well-ordered knowledge on every conceivable branch of the work of the live stock farmer; probably without an equal in this or any other country."

"The best and brightest guide to the practice of husbandry, one that has no superior—no equal we might truly say—among the agricultural literature now before the public. . . In every section in which we have tested it, the work has been found thoroughly up to date."—*Bell's Weekly Messenger*.

British Farm Live Stock.

FARM LIVE STOCK OF GREAT BRITAIN. By ROBERT WALLACE, F.L.S., F.R.S.E., &c., Professor of Agriculture and Rural Economy in the University of Edinburgh. Third Edition, thoroughly Revised and considerably Enlarged. With over 120 Phototypes of Prize Stock. Demy 8vo, 384 pp., with 70 Plates and Maps, 12s. 6d. cloth.

"A really complete work on the history, breeds, and management of the farm stock of Great Britain, and one which is likely to find its way to the shelves of every country gentleman's library."—*The Times*.

"The latest edition of 'Farm Live Stock of Great Britain' is a production to be proud of, and its issue not the least of the services which its author has rendered to agricultural science."

"The book is very attractive . . . and we can scarcely imagine the existence of a farmer who would not like to have a copy of this beautiful work."—*Mark Lane Express*.

"A work which will long be regarded as a standard authority whenever a concise history and description of the breeds of live stock in the British Isles is required."—*Bell's Weekly Messenger*.

Dairy Farming.

BRITISH DAIRYING. A Handy Volume on the Work of the Dairy-Farm. For the Use of Technical Instruction Classes, Students in Agricultural Colleges, and the Working Dairy-Farmer. By Prof. J. P. SHELDON, late Special Commissioner of the Canadian Government, Author of "Dairy Farming," &c. With numerous illustrations. Crown 8vo, 2s. 6d. cloth.

"May be confidently recommended as a useful text-book on dairy farming."—*Agricultural Gazette*.

"Probably the best half-crown manual on dairy work that has yet been produced."—*North British Agriculturist*.

"It is the soundest little work we have yet seen on the subject."—*The Times*.

Dairy Manual.

MILK, CHEESE AND BUTTER: A Practical Handbook on their Properties and the Processes of their Production, including a Chapter on Cream and the Methods of its Separation from Milk. By JOHN OLIVER, late Principal of the Western Dairy Institute, Berkeley. With Coloured Plates and 200 Illusts. Crown 8vo, 7s. 6d. cloth. [Just published.

Agricultural Facts and Figures.

NOTE-BOOK OF AGRICULTURAL FACTS AND FIGURES FOR FARMERS AND FARM STUDENTS. By PRIMROSE MCCONNELL, B.Sc. Fifth Edition. Royal 32mo, roan, gilt edges, with band, 4s.

"Literally teems with information, and we can cordially recommend it to all connected with agriculture."—*North British Agriculturist*.

Small Farming.

SYSTEMATIC SMALL FARMING; or, The Lessons of my Farm. Being an Introduction to Modern Farm Practice for Small Farmers. By ROBERT SCOTT BURN, Author of "Outlines of Modern Farming," &c. With numerous illustrations, crown 8vo, 6s. cloth.

"This is the completest book of its class we have seen, and one which every amateur farmer will read with pleasure and accept as a guide."—*Field*.

Modern Farming.

OUTLINES OF MODERN FARMING. By R. SCOTT BURN. Soils, Manures, and Crops—Farming and Farming Economy—Cattle, Sheep, and Horses—Management of Dairy, Pigs, and Poultry—Utilisation of Town-Sewage, Irrigation, &c. Sixth Edition. In One Vol., 1,250 pp., half-bound, profusely illustrated, 12s.

"The aim of the author has been to make his work at once comprehensive and trustworthy and he has succeeded to a degree which entitles him to much credit."—*Morning Advertiser*.

Agricultural Engineering.

FARM ENGINEERING, THE COMPLETE TEXT-BOOK OF. Comprising Draining and Embanking; Irrigation and Water Supply; Farm Roads, Fences, and Gates; Farm Buildings; Barn Implements and Machines; Field implements and Machines; Agricultural Surveying, &c. By Prof. JOHN SCOTT. In One Vol., 1,150 pages, half-bound, with over 600 illustrations, 12s.

"Written with great care, as well as with knowledge and ability. The author has done his work well; we have found him a very trustworthy guide wherever we have tested his statements. The volume will be of great value to agricultural students."—*Mark Lane Express*.

Agricultural Text-Book.

THE FIELDS OF GREAT BRITAIN: A Text-Book of Agriculture, adapted to the Syllabus of the Science and Art Department. For Elementary and Advanced Students. By HUGH CLEMENTS (Board of Trade). Second Edition, Revised, with Additions. 18mo, 2s. 6d. cloth.

"A most comprehensive volume, giving a mass of information."—*Agricultural Economist*.

"It is a long time since we have seen a book which has pleased us more, or which contains such a vast and useful fund of knowledge."—*Educational Times*.

Tables for Farmers, etc.

TABLES, MEMORANDA, AND CALCULATED RESULTS for Farmers, Graziers, Agricultural Students, Surveyors, Land Agents, Auctioneers, etc. With a New System of Farm Book-keeping. Selected and Arranged by SIDNEY FRANCIS. Third Edition, Revised. 272 pp., waistcoat-pocket size, 1s. 6d., limp leather.

"Weighing less than 1 oz., and occupying no more space than a match box, it contains a mass of facts and calculations which has never before, in such handy form, been obtainable. Every operation on the farm is dealt with. The work may be taken as thoroughly accurate, the whole of the tables having been revised by Dr. Fream. We cordially recommend it."—*Bell's Weekly Messenger*.

The Management of Bees.

BEEES FOR PLEASURE AND PROFIT: A Guide to the Manipulation of Bees, the Production of Honey, and the General Management of the Apary. By G. GORDON SAMSON. With numerous Illustrations. Crown 8vo, 1s. cloth.

"The intending bee-keeper will find exactly the kind of information required to enable him to make a successful start with his hives. The author is a thoroughly competent teacher, and his book may be commended."—*Morning Post*.

Farm and Estate Book-keeping.

BOOK-KEEPING FOR FARMERS & ESTATE OWNERS.

A Practical Treatise, presenting, in Three Plans, a System adapted for all Classes of Farms. By JOHNSON M. WOODMAN, Chartered Accountant. Second Edition, Revised. Crown 8vo, 3s. 6d. cloth boards; or 2s. 6d. cloth limp.

"The volume is a capital study of a most important subject."—*Agricultural Gazette*.

"The young farmer, land agent, and surveyor will find Mr. Woodman's treatise more than repay its cost and study."—*Building News*.

Farm Account Book.

WOODMAN'S YEARLY FARM ACCOUNT BOOK. Giving a Weekly Labour Account and Diary, and showing the Income and Expenditure under each Department of Crops, Live Stock, Dairy, &c. &c. With Valuation, Profit and Loss Account, and Balance Sheet at the end of the Year. By JOHNSON M. WOODMAN, Chartered Accountant, Author of "Book-keeping for Farmers." Folio, 7s. 6d. half bound.

"Contains every requisite form for keeping farm accounts readily and accurately."—*Agri-*

Early Fruits, Flowers, and Vegetables.

THE FORCING GARDEN; or, How to Grow Early Fruits, Flowers, and Vegetables. With Plans and Estimates for Building Glass-houses, Pits, and Frames. With Illustrations. By SAMUEL WOOD. Crown 8vo, 3s. 6d. cloth.

"A good book, and fairly fills a place that was in some degree vacant." The book is written with great care, and contains a great deal of valuable teaching."—*Gardeners' Magazine*.

Good Gardening.

A PLAIN GUIDE TO GOOD GARDENING; or, How to Grow Vegetables, Fruits, and Flowers. By S. WOOD. Fourth Edition, with considerable Additions, &c., and numerous Illustrations. Crown 8vo, 3s. 6d. cl.

"A very good book, and one to be highly recommended as a practical guide. The practical directions are excellent."—*Athenaeum*.

"May be recommended to young gardeners, cottagers, and specially to amateurs, for the plain, simple, and trustworthy information it gives on common matters too often neglected."—*Gardeners' Chronicle*.

Gainful Gardening.

MULTUM-IN-PARVO GARDENING; or, How to make One Acre of Land produce £620 a-year by the Cultivation of Fruits and Vegetables; also, How to Grow Flowers in Three Glass Houses, so as to realise £176 per annum clear Profit. By SAMUEL WOOD, Author of "Good Gardening," &c. Fifth and Cheaper Edition, Revised, with Additions. Crown 8vo, 1s. sewed.

"We are bound to recommend it as not only suited to the case of the amateur and gentleman's gardener, but to the market grower."—*Gardeners' Magazine*.

Gardening for Ladies.

THE LADIES' MULTUM-IN-PARVO FLOWER GARDEN, and Amateurs' Complete Guide. With Illusts. By S. WOOD. Cr. 8vo, 3s. 6d. cl.

"This volume contains a good deal of sound common sense instruction."—*Florist*.

"Full of shrewd hints and useful instructions, based on a lifetime of experience."—*Scotsman*.

Receipts for Gardeners.

GARDEN RECEIPTS. Edited by CHARLES W. QUIN. 12mo, 1s. 6d. cloth limp.

"A useful and handy book, containing a good deal of valuable information."—*Athenaeum*.

Market Gardening.

MARKET AND KITCHEN GARDENING. By Contributors to "The Garden." Compiled by C. W. SHAW, late Editor of "Gardening Illustrated." 12mo, 3s. 6d. cloth boards.

"The most valuable compendium of kitchen and market-garden work published."—*Farmer*.

Cottage Gardening.

COITAGE GARDENING; or, Flowers, Fruits, and Vegetables or Small Gardens. By E. HOBDAV. 12mo, 1s. 6d. cloth limp.

"Contains much useful information at a small charge."—*Glasgow Herald*.

AUCTIONEERING, VALUING, LAND SURVEYING ESTATE AGENCY, etc.

Auctioneer's Assistant.

THE APPRAISER, AUCTIONEER, BROKER, HOUSE AND ESTATE AGENT AND VALUER'S POCKET ASSISTANT, for the Valuation for Purchase, Sale, or Renewal of Leases, Annuities and Reversions, and of property generally; with Prices for Inventories, &c. By JOHN WHEELER, Valuer, &c. Sixth Edition, Re-written and greatly extended by C. NORRIS, Surveyor, Valuer, &c. Royal 32mo, 5s. cloth.

"A neat and concise book of reference, containing an admirable and clearly-arranged list of prices for inventories, and a very practical guide to determine the value of furniture, &c."—*Standard*.

"Contains a large quantity of varied and useful information as to the valuation for purchase, sale, or renewal of leases, annuities and reversions, and of property generally, with prices for inventories, and a guide to determine the value of interior fittings and other effects."—*Builder*.

Auctioneering.

AUCTIONEERS: THEIR DUTIES AND LIABILITIES.

A Manual of Instruction and Counsel for the Young Auctioneer. By ROBERT SQUIBBS, Auctioneer. Second Edition, Revised and partly Re-written. Demy 8vo, 12s. 6d. cloth.

** OPINIONS OF THE PRESS.

"The standard text-book on the topics of which it treats."—*Athenaeum*.

"The work is one of general excellent character, and gives much information in a compendious and satisfactory form."—*Builder*.

"May be recommended as giving a great deal of information on the law relating to auctioneers, in a very readable form."—*Law Journal*.

"Auctioneers may be congratulated on having so pleasing a writer to minister to their special needs."—*Solicitors' Journal*.

"Every auctioneer ought to possess a copy of this excellent work."—*Ironmonger*.

"Of great value to the profession. . . . We readily welcome this book from the fact that it treats the subject in a manner somewhat new to the profession."—*Estates Gazette*.

Inwood's Estate Tables.

TABLES FOR THE PURCHASING OF ESTATES, Freehold, Copyhold, or Leasehold; Annuities, Advertisements, etc., and for the Renewing of Leases held under Cathedral Churches, Colleges, or other Corporate bodies, for Terms of Years certain, and for Lives; also for Valuing Reversionary Estates, Deferred Annuities, Next Presentations, &c.; together with SMART'S Five Tables of Compound Interest, and an Extension of the same to Lower and Intermediate Rates. By W. INWOOD. 24th Edition, with considerable Additions, and new and valuable Tables of Logarithms for the more Difficult Computations of the Interest of Money, Discount, Annuities, &c., by M. FEDOR THOMAN, of the Société Crédit Mobilier of Paris. Crown 8vo, 8s. cloth.

"Those interested in the purchase and sale of estates, and in the adjustment of compensation cases, as well as in transactions in annuities, life insurances, &c., will find the present edition of eminent service."—*Engineering*.

"Inwood's Tables' still maintain a most enviable reputation. The new issue has been enriched by large additional contributions by M. Fedor Thoman, whose carefully arranged Tables cannot fail to be of the utmost utility."—*Mining Journal*.

Agricultural Valuer's Assistant.

THE AGRICULTURAL VALUER'S ASSISTANT. A Practical Handbook on the Valuation of Landed Estates; including Rules and Data for Measuring and Estimating the Contents, Weights, and Values of Agricultural Produce and Timber, and the Values of Feeding Stuffs, Manures, and Labour; with Forms of Tenant-Right-Valuations, Lists of Local Agricultural Customs, Scales of Compensation under the Agricultural Holdings Act, &c. &c. By TOM BRIGHT, Agricultural Surveyor. Second Edition, much Enlarged. Crown 8vo, 5s. cloth.

"Full of tables and examples in connection with the valuation of tenant-right, estates, labour, contents, and weights of timber, and farm produce of all kinds."—*Agricultural Gazette*.

"An eminently practical handbook, full of practical tables and data of undoubted interest and value to surveyors and auctioneers in preparing valuations of all kinds."—*Farmer*.

Plantations and Underwoods.

POLE PLANTATIONS AND UNDERWOODS: A Practical Handbook on Estimating the Cost of Forming, Renovating, Improving, and Grubbing Plantations and Underwoods, their Valuation for Purposes of Transfer, Rental, Sale, or Assessment. By TOM BRIGHT, Author of "The Agricultural Valuer's Assistant," &c. Crown 8vo, 3s. 6d. cloth.

"To valuers, foresters and agents it will be a welcome aid."—*North British Agriculturist*.

"Well calculated to assist the valuer in the discharge of his duties, and of undoubted interest and use both to surveyors and auctioneers in preparing valuations of all kinds."—*Kent Herald*.

Hudson's Land Valuer's Pocket-Book.

THE LAND VALUER'S BEST ASSISTANT: Being Tables on a very much Improved Plan, for Calculating the Value of Estates. With Tables for reducing Scotch, Irish, and Provincial Customary Acres to Statute Measure, &c. By R. HUDSON, C.E. New Edition. Royal 32mo, leather, elastic band, 4s.

"Of incalculable value to the country gentleman and professional man."—*Farmers' Journal*

Ewart's Land Improver's Pocket-Book.

THE LAND IMPROVER'S POCKET-BOOK OF FORMULÆ, TABLES, and MEMORANDA required in any Computation relating to the Permanent Improvement of Landed Property. By JOHN EWART, Land Surveyor and Agricultural Engineer. Second Edition, Revised. Royal 32mo, oblong leather, gilt edges, with elastic band, 4s.

"A compendious and handy little volume."—*Spectator*.

Complete Agricultural Surveyor's Pocket-Book.

THE LAND VALUER'S AND LAND IMPROVER'S COMPLETE POCKET-BOOK. Being of the above Two Works bound together. Leather, with strap, 7s. 6d.

House Property.

HANDBOOK OF HOUSE PROPERTY. A Popular and Practical Guide to the Purchase, Mortgage, Tenancy, and Compulsory Sale of Houses and Land, including the Law of Dilapidations and Fixtures; with Examples of all kinds of Valuations, Useful Information on Building, and Suggestive Elucidations of Fine Art. By E. L. TARBUCK, Architect and Surveyor. Fifth Edition, Enlarged. 12mo, 5s. cloth.

"The advice is thoroughly practical."—*Law Journal*.

"For all who have dealings with house property, this is an indispensable guide."—*Decoration*.

"Carefully brought up to date, and much improved by the addition of a division on fine art. . . . A well-written and thoughtful work."—*Land Agent's Record*.

LAW AND MISCELLANEOUS.

Private Bill Legislation and Provisional Orders.

HANDBOOK FOR THE USE OF SOLICITORS AND ENGINEERS Engaged in Promoting Private Acts of Parliament and Provisional Orders, for the Authorization of Railways, Tramways, Works for the Supply of Gas and Water, and other undertakings of a like character. By L. LIVINGSTON MACASSEY, of the Middle Temple, Barrister-at-Law, M.Inst.C.E.; Author of "Hints on Water Supply." Demy 8vo, 950 pp., 25s. cl.

"The author's double experience as an engineer and barrister has enabled him to approach the subject alike from an engineering and legal point of view."—*Local Government Chronicle*.

Law of Patents.

PATENTS FOR INVENTIONS, AND HOW TO PROCURE THEM. Compiled for the Use of Inventors, Patentees and others. By G. G. M. HARDINGHAM, Assoc. Mem. Inst. C.E., &c. Demy 8vo, 1s. 6d., cloth.

Labour Disputes.

CONCILIATION AND ARBITRATION IN LABOUR DISPUTES: A Historical Sketch and Brief Statement of the Present Position of the Question at Home and Abroad. By J. S. JEANS, Author of "England's Supremacy," &c. Crown 8vo, 200 pp., 2s. 6d. cloth. [Just published.]

Pocket-Book for Sanitary Officials.

THE HEALTH OFFICER'S POCKET-BOOK: A Guide to Sanitary Practice and Law. For Medical Officers of Health, Sanitary Inspectors, Members of Sanitary Authorities, &c. By EDWARD F. WILLOUGHBY, M.D. (Lond.), &c., Author of "Hygiene and Public Health." Fcap. 8vo, 7s. 6d., cloth, red edges, rounded corners. [Just published.]

"A mine of condensed information of a pertinent and useful kind on the various subjects of which it treats. The matter seems to have been carefully compiled and arranged for facility of reference, and it is well illustrated by diagrams and woodcuts. The different subjects are succinctly but fully and scientifically dealt with."—*The Lancet*.

"Ought to be welcome to those for whose use it is designed, since it practically boils down a reference library into a pocket volume. . . . It combines, with an uncommon degree of efficiency, the qualities of accuracy, conciseness and comprehensiveness."—*Scotsman*.

"An excellent publication, dealing with the scientific, technical and legal matters connected with the duties of medical officers of health and sanitary inspectors. The work is replete with information."—*Local Government Journal*.

A Complete Epitome of the Laws of this Country.

EVERY MAN'S OWN LAWYER: A Handy-Book of the Principles of Law and Equity. By A BARRISTER. Thirty-first Edition, carefully Revised, and including the Legislation of 1893. Comprising (amongst other Acts) the *Voluntary Conveyances Act, 1893*; the *Married Women's Property Act, 1893*; the *Trustee Act, 1893*; the *Savings Bank Act, 1893*; the *Barbed Wire Act, 1893*; the *Industrial and Provident Societies Act, 1893*; the *Hours of Labour of Railway Servants Act, 1893*; the *Fertiliser and Feeding Stuffs Act, 1893*, &c., as well as the *Betting and Loans (Infants) Act, 1892*; the *Gaming Act, 1892*; the *Shop Hours Act, 1892*; the *Conveyancing and Real Property Act, 1892*; the *Small Holdings Act, 1892*; and many other new Acts. Crown 8vo, 700 pp., price 6s. 8d. (saved at every consultation!), strongly bound in cloth. [Just published.]

* * * The Book will be found to comprise (amongst other matter)—

THE RIGHTS AND WRONGS OF INDIVIDUALS—LANDLORD AND TENANT—VENDORS AND PURCHASERS—PARTNERS AND AGENTS—COMPANIES AND ASSOCIATIONS—MASTERS, SERVANTS, AND WORKMEN—LEASES AND MORTGAGES—LIBEL AND SLANDER—CONTRACTS AND AGREEMENTS—BONDS AND BILLS OF SALE—CHEQUES, BILLS, AND NOTES—RAILWAY AND SHIPPING LAW—BANKRUPTCY AND INSURANCE—BORROWERS, LENDERS AND SURETIES—CRIMINAL LAW—PARLIAMENTARY ELECTIONS—COUNTY COUNCILS—MUNICIPAL CORPORATIONS—PARISH LAW, CHURCH-WARDENS, ETC.—PUBLIC HEALTH AND NUISANCES—COPYRIGHT AND PATENTS—TRADE MARKS AND DESIGNS—HUSBAND AND WIFE, DIVORCE, ETC.—TRUSTEES AND EXECUTORS—GUARDIAN AND WARD, INFANTS, ETC.—GAME LAWS AND SPORTING—HORSES, HORSE DEALING, AND DOGS—INN-KEEPERS, LICENSING, ETC.—FORMS OF WILLS, AGREEMENTS ETC. ETC.

☞ The object of this work is to enable those who consult it to help themselves to the law; and thereby to dispense, as far as possible, with professional assistance and advice. There are many wrongs and grievances which persons submit to from time to time through not knowing how or where to apply for redress; and many persons have as great a dread of a lawyer's office as of a lion's den. With this book at hand it is believed that many a SIX-AND-EIGHTPENCE may be saved; many a wrong redressed; many a right reclaimed; many a law suit avoided; and many an evil abated. The work has established itself as the standard legal adviser of all classes, and has also made a reputation for itself as a useful book of reference for lawyers residing at a distance from law libraries, who are glad to have at hand a work embodying recent decisions and enactments.

* * * OPINIONS OF THE PRESS.

"It is a complete code of English Law, written in plain language, which all can understand. Should be in the hands of every business man, and all who wish to abolish lawyers' bills."—*Weekly Times*.

"A useful and concise epitome of the law, compiled with considerable care."—*Law Magazine*.

"A complete digest of the most useful facts which constitute English law."—*Globe*.

"This excellent handbook. . . . Admirably done, admirably arranged, and admirably cheap."—*Leeds Mercury*.

"A concise, cheap and complete epitome of the English law. So plainly written that he who runs may read, and he who reads may understand."—*Figaro*.

"A dictionary of legal facts well put together. The book is a very useful one."—*Spectator*.

"A work which has long been wanted, which is thoroughly well done, and which we most cordially recommend."—*Sunday Times*.

"The latest edition of this popular book ought to be in every business establishment, and on every library table."—*Sheffield Post*.

"A complete epitome of the law; thoroughly intelligible to non-professional readers."

Bell's Life.

Legal Guide for Pawnbrokers.

THE PAWNBROKERS', FACTORS' AND MERCHANTS' GUIDE TO THE LAW OF LOANS AND PLEDGES. With the Statutes and a Digest of Cases. By H. C. FOLKARD, Esq., Barrister-at-Law. Fcap. 8vo, 3s. 6d. cloth.

The Law of Contracts.

LABOUR CONTRACTS: A Popular Handbook on the Law of Contracts for Works and Services. By DAVID GIBBONS. Fourth Edition, Appendix of Statutes by T. F. UTTLEY, Solicitor. Fcap. 8vo, 3s. 6d. cloth.

The Factory Acts.

SUMMARY OF THE FACTORY AND WORKSHOP ACTS (1878-1891). For the Use of Manufacturers and Managers. By EMILE GARCKE and J. M. FELLOES. (Reprinted from "FACTORY ACCOUNTS.") Crown 8vo, 6d. sewed.

ODDEN, SMALE AND CO. LIMITED, PRINTERS, GREAT SAFFRON HILL, E.C.

WEALE'S Rudimentary Series.



LONDON, 1862.
THE PRIZE MEDAL

Was awarded to the Publishers of



WEALE'S SERIES

RUDIMENTARY SCIENTIFIC, EDUCATIONAL,
AND CLASSICAL.

Comprising nearly Three Hundred and Fifty distinct works in almost every department of Science, Art, and Education, recommended to the notice of Engineers, Architects, Builders, Artisans, and Students generally, as well as to those interested in Workmen's Libraries, Literary and Scientific Institutions, Colleges, Schools, Science Classes, &c., &c.

“WEALE'S SERIES includes Text-Books on almost every branch of Science and Industry, comprising such subjects as Agriculture, Architecture and Building, Civil Engineering, Fine Arts, Mechanics and Mechanical Engineering, Physical and Chemical Science, and many miscellaneous Treatises. The whole are constantly undergoing revision, and new editions, brought up to the latest discoveries in scientific research, are constantly issued. The prices at which they are sold are as low as their excellence is assured.”—*American Literary Gazette*.

“Amongst the literature of technical education, WEALE'S SERIES has enjoyed a high reputation, and the additions being made by Messrs. CROSBY LOCKWOOD & SON render the series more complete, and bring the information upon the several subjects down to the present time.”—*Mining Journal*.

“It is not too much to say that no books have ever proved more popular with, or more useful to, young engineers and others than the excellent treatises comprised in WEALE'S SERIES.”—*Engineer*.

“The excellence of WEALE'S SERIES is now so well appreciated, that it would be wasting our space to enlarge upon their general usefulness and value.”—*Builder*.

“The volumes of WEALE'S SERIES form one of the best collections of elementary technical books in any language.”—*Architect*.

“WEALE'S SERIES has become a standard as well as an unrivalled collection of treatises in all branches of art and science.”—*Public Opinion*.



PHILADELPHIA, 1876.
THE PRIZE MEDAL

Was awarded to the Publishers for
Books: Rudimentary, Scientific,
“WEALE'S SERIES,” ETC.



CROSBY LOCKWOOD & SON,

7, STATIONERS' HALL COURT, LUDGATE HILL, LONDON, E.C.

*** Catalogues post free on application*

WEALE'S RUDIMENTARY SCIENTIFIC SERIES.



. The volumes of this Series are freely Illustrated with Woodcuts, or otherwise, where requisite. Throughout the following List it must be understood that the books are bound in limp cloth, unless otherwise stated; but the volumes marked with a ‡ may also be had strongly bound in cloth boards for 6d. extra.

N.B.—In ordering from this List it is recommended, as a means of facilitating business and obviating error, to quote the numbers affixed to the volumes, as well as the titles and prices.

CIVIL ENGINEERING, SURVEYING, ETC.


- No.
31. **WELLS AND WELL-SINKING.** By JOHN GEO. SWINDELL, A.R.I.B.A., and G. R. BURNELL, C.E. Revised Edition. With a New Appendix on the Qualities of Water. Illustrated. 2s.
 35. **THE BLASTING AND QUARRYING OF STONE,** for Building and other Purposes. By Gen. Sir J. BURGOYNE, Bart. 1s. 6d.
 43. **TUBULAR, AND OTHER IRON GIRDER BRIDGES,** particularly describing the Britannia and Conway Tubular Bridges. By G. DRAYDALE DEMPSEY, C.E. Fourth Edition. 2s.
 44. **FOUNDATIONS AND CONCRETE WORKS,** with Practical Remarks on Footings, Sand, Concrete, Béton, Pile-driving, Caissons, and Cofferdams, &c. By E. DOBSON. Seventh Edition. 1s. 6d.
 60. **LAND AND ENGINEERING SURVEYING.** By T. BAKER, C.E. Fifteenth Edition, revised by Professor J. R. YOUNG. 2s.‡
 - 80*. **EMBANKING LANDS FROM THE SEA.** With examples and Particulars of actual Embankments, &c. By J. WIGGINS, F.G.S. 2s.
 81. **WATER WORKS,** for the Supply of Cities and Towns. With a Description of the Principal Geological Formations of England as influencing Supplies of Water, &c. By S. HUGHES, C.E. New Edition. 4s.‡
 118. **CIVIL ENGINEERING IN NORTH AMERICA,** a Sketch of. By DAVID STEVENSON, F.R.S.E., &c. Plates and Diagrams. 3s.
 167. **IRON BRIDGES, GIRDERS, ROOFS, AND OTHER WORKS.** By FRANCIS CAMPIN, C.E. 2s. 6d.‡
 197. **ROADS AND STREETS.** By H. LAW, C.E., revised and enlarged by D. K. CLARK, C.E., including pavements of Stone, Wood, Asphalts, &c. 4s. 6d.‡
 203. **SANITARY WORK IN THE SMALLER TOWNS AND IN VILLAGES.** By C. SLAGG, A.M.I.C.E. Revised Edition. 3s.‡
 212. **GAS-WORKS, THEIR CONSTRUCTION AND ARRANGEMENTS;** and the Manufacture and Distribution of Coal Gas. Originally written by SAMUEL HUGHES, C.E. Re-written and enlarged by WILLIAM RICHARDS, C.E. Eighth Edition, with important additions. 5s. 6d.‡
 213. **PIONEER ENGINEERING.** A Treatise on the Engineering Operations connected with the Settlement of Waste Lands in New Countries. By EDWARD DOBSON, Assoc. Inst. C.E. 4s. 6d.‡
 216. **MATERIALS AND CONSTRUCTION;** A Theoretical and Practical Treatise on the Strains, Designing, and Erection of Works of Construction. By FRANCIS CAMPIN, C.E. Second Edition, revised. 3s.‡
 219. **CIVIL ENGINEERING.** By HENRY LAW, M.Inst. C.E. Including HYDRAULIC ENGINEERING by GEO. R. BURNELL, M.Inst. C.E. Seventh Edition, revised, with large additions by D. KINNAR CLARK, M.Inst. C.E. 6s. 6d., Cloth boards, 7s. 6d.
 268. **THE DRAINAGE OF LANDS, TOWNS, & BUILDINGS.** By G. D. DEMPSEY, C.E. Revised, with large Additions on Recent Practice in Drainage Engineering, by D. KINNAR CLARK, M.I.C.E. Second Edition, Corrected. 4s. 6d.‡

‡ The ‡ indicates that these vols. may be had strongly bound at 6d. extra.

LONDON: CROSBY LOCKWOOD AND SON,

MECHANICAL ENGINEERING, ETC.

33. **CRANES**, the Construction of, and other Machinery for Raising Heavy Bodies. By JOSEPH GLYNN, F.R.S. Illustrated. 1s. 6d.
34. **THE STEAM ENGINE**. By Dr. LARDNER. Illustrated. 1s. 6d.
59. **STEAM BOILERS**: their Construction and Management. By R. ARMSTRONG, C.E. Illustrated. 1s. 6d.
82. **THE POWER OF WATER**, as applied to drive Flour Mills, and to give motion to Turbines, &c. By JOSEPH GLYNN, F.R.S. 2s. 2.
98. **PRACTICAL MECHANISM**, the Elements of; and Machine Tools. By T. BAKER, C.E. With Additions by J. NASMYTH, C.E. 2s. 6d. 2
139. **THE STEAM ENGINE**, a Treatise on the Mathematical Theory of, with Rules and Examples for Practical Men. By T. BAKER, C.E. 1s. 6d.
164. **MODERN WORKSHOP PRACTICE**, as applied to Steam Engines, Bridges, Ship-building, &c. By J. G. WINTON. New Edition. 3s. 6d. 2
165. **IRON AND HEAT**, exhibiting the Principles concerned in the Construction of Iron Beams, Pillars, and Girders. By J. ARMOUR. 2s. 6d. 2
166. **POWER IN MOTION**: Horse-Power, Toothed-Wheel Gearing, Long and Short Driving Bands, and Angular Forces. By J. ARMOUR. 2s. 2
171. **THE WORKMAN'S MANUAL OF ENGINEERING DRAWING**. By J. MAXTON. 7th Edn. With 7 Plates and 350 Cuts. 3s. 6d. 2
190. **STEAM AND THE STEAM ENGINE**, Stationary and Portable. By J. SEWELL and D. K. CLARK, C.E. 3s. 6d. 2
200. **FUEL**, its Combustion and Economy. By C. W. WILLIAMS. With Recent Practice in the Combustion and Economy of Fuel—Coal, Coke, Wood, Peat, Petroleum, &c.—by D. K. CLARK, M.I.C.E. 3s. 6d. 2
202. **LOCOMOTIVE ENGINES**. By G. D. DEMPSEY, C.E.; with large additions by D. KINNEAR CLARK, M.I.C.E. 3s. 2
211. **THE BOILERMAKER'S ASSISTANT** in Drawing, Templating, and Calculating Boiler and Tank Work. By JOHN COURTNEY, Practical Boiler Maker. Edited by D. K. CLARK, C.E. 100 Illustrations. 2s.
217. **SEWING MACHINERY**: Its Construction, History, &c., with full Technical Directions for Adjusting, &c. By J. W. URQUHART, C.E. 2s. 2
223. **MECHANICAL ENGINEERING**. Comprising Metallurgy, Moulding, Casting, Forging, Tools, Workshop Machinery, Manufacture of the Steam Engine, &c. By FRANCIS CAMPIN, C.E. Second Edition. 2s. 6d. 2
236. **DETAILS OF MACHINERY**. Comprising Instructions for the Execution of various Works in Iron. By FRANCIS CAMPIN, C.E. 3s. 2
237. **THE SMITHY AND FORGE**; including the Farrier's Art and Coach Smithing. By W. J. E. CRANE. Illustrated. 2s. 6d. 2
238. **THE SHEET-METAL WORKER'S GUIDE**; a Practical Handbook for Tinsmiths, Coppersmiths, Zincworkers, &c. With 94 Diagrams and Working Patterns. By W. J. E. CRANE. Second Edition, revised. 1s. 6d.
251. **STEAM AND MACHINERY MANAGEMENT**: with Hints on Construction and Selection. By M. POWIS BALE, M.I.M.E. 2s. 6d. 2
254. **THE BOILERMAKER'S READY-RECKONER**. By J. COURTNEY. Edited by D. K. CLARK, C.E. 4s.
- * Nos. 251 and 254 in One Vol., half-bound, entitled "THE BOILERMAKER'S READY-RECKONER AND ASSISTANT." By J. COURTNEY and D. K. CLARK. 7s.
255. **LOCOMOTIVE ENGINE-DRIVING**. A Practical Manual for Engineers in charge of Locomotive Engines. By MICHAEL REYNOLDS, M.S.E. Eighth Edition. 3s. 6d., limp; 4s. 6d. cloth boards.
256. **STATIONARY ENGINE-DRIVING**. A Practical Manual for Engineers in charge of Stationary Engines. By MICHAEL REYNOLDS, M.S.E. Fourth Edition. 3s. 6d., limp; 4s. 6d. cloth boards.
260. **IRON BRIDGES OF MODERATE SPAN**: their Construction and Erection. By HAMILTON W. PENDRED, C.E. 2s.

 The 2 indicates that these vols. may be had strongly bound at 6d. extra.


7, STATIONERS' HALL COURT, LUDGATE HILL, E.C.

MINING, METALLURGY, ETC.

4. **MINERALOGY**, Rudiments of; a concise View of the General Properties of Minerals. By A. RAMSAY, F.G.S., F.R.G.S., &c. Third Edition, revised and enlarged. Illustrated. 3s. 6d.‡
117. **SUBTERRANEAN SURVEYING**, with and without the Magnetic Needle. By T. FENWICK and T. BAKER, C.E. Illustrated. 2s. 6d.‡
135. **ELECTRO-METALLURGY**; Practically Treated. By ALEXANDER WATT. Ninth Edition, enlarged and revised, with additional Illustrations, and including the most recent Processes. 3s. 6d.‡
172. **MINING TOOLS**, Manual of. For the Use of Mine Managers, Agents, Students, &c. By WILLIAM MORGANS. 2s. 6d.‡
- 172*. **MINING TOOLS, ATLAS** of Engravings to Illustrate the above, containing 235 Illustrations, drawn to Scale. 4to. 4s. 6d.
176. **METALLURGY OF IRON**. Containing History of Iron Manufacture, Methods of Assay, and Analyses of Iron Ores, Processes of Manufacture of Iron and Steel, &c.. By H. BAUERMANN, F.G.S. Sixth Edition, revised and enlarged. 5s.‡
180. **COAL AND COAL MINING**. By the late Sir WARINGTON W. SMYTH, M.A., F.R.S. Seventh Edition, revised. 3s. 6d.‡
195. **THE MINERAL SURVEYOR AND VALUER'S COMPLETE GUIDE**. By W. LINTERN, M.E. Third Edition, including Magnetic and Angular Surveying. With Four Plates. 3s. 6d.‡
214. **SLATE AND SLATE QUARRYING**, Scientific, Practical, and Commercial. By D. C. DAVIES, F.G.S., Mining Engineer, &c. 3s.‡
264. **A FIRST BOOK OF MINING AND QUARRYING**, with the Sciences connected therewith, for Primary Schools and Self Instruction. By J. H. COLLINS, F.G.S. Second Edition, with additions. 1s. 6d.

ARCHITECTURE, BUILDING, ETC.

16. **ARCHITECTURE—ORDERS**—The Orders and their Æsthetic Principles. By W. H. LEEDS. Illustrated. 1s. 6d.
17. **ARCHITECTURE—STYLES**—The History and Description of the Styles of Architecture of Various Countries, from the Earliest to the Present Period. By T. TALBOT BURY, F.R.I.B.A., &c. Illustrated. 2s.
*^o **ORDERS AND STYLES OF ARCHITECTURE**, in *One Vol.*, 3s. 6d.
18. **ARCHITECTURE—DESIGN**—The Principles of Design in Architecture, as deducible from Nature and exemplified in the Works of the Greek and Gothic Architects. By E. L. GARRETT, Architect. Illustrated. 2s. 6d.
- *^o *The three preceding Works, in One handsome Vol., half bound, entitled "MODERN ARCHITECTURE," price 6s.*
22. **THE ART OF BUILDING**, Rudiments of. General Principles of Construction, Materials used in Building, Strength and Use of Materials, Working Drawings, Specifications, and Estimates. By E. DOBSON, 2s.‡
25. **MASONRY AND STONECUTTING**: Rudimentary Treatise on the Principles of Masonic Projection and their application to Construction. By EDWARD DOBSON, M.R.I.B.A., &c. 2s. 6d.‡
42. **COTTAGE BUILDING**. By C. BRUCE ALLEN, Architect. Eleventh Edition, revised and enlarged. With a Chapter on Economic Cottages for Allotments, by EDWARD E. ALLEN, C.E. 2s.
45. **LIMES, CEMENTS, MORTARS, CONCRETES, MASTICS, PLASTERING**, &c. By G. R. BURNELL, C.E. Fourteenth Edition. 1s. 6d.
57. **WARMING AND VENTILATION**. An Exposition of the General Principles as applied to Domestic and Public Buildings, Mines, Lighthouses, Ships, &c. By C. TOMLINSON, F.R.S., &c. Illustrated. 3s.
111. **ARCHES, PIERS, BUTTRESSES, &c.**: Experimental Essays on the Principles of Construction. By W. BLAND. Illustrated. 1s. 6d.

 *The ‡ indicates that these vols. may be had strongly bound at 6d. extra.*

LONDON: CROSBY LOCKWOOD AND SON,

Architecture, Building, etc., *continued.*

116. **THE ACOUSTICS OF PUBLIC BUILDINGS**; or, The Principles of the Science of Sound applied to the purposes of the Architect and Builder. By T. ROGER SMITH, M.K.I.B.A., Architect. Illustrated. 1s. 6d.
127. **ARCHITECTURAL MODELLING IN PAPER**, the Art of. By T. A. RICHARDSON, Architect. Illustrated. 1s. 6d.
128. **VITRUVIUS—THE ARCHITECTURE OF MARCUS VITRUVIUS POLLO**. In Ten Books. Translated from the Latin by JOSEPH GWILT, F.S.A., F.R.A.S. With 23 Plates. 5s.
130. **GRECIAN ARCHITECTURE**, An Inquiry into the Principles of Beauty in; with an Historical View of the Rise and Progress of the Art in Greece. By the EARL OF ABERDEEN. 1s.
- * The two preceding Works in One handsome Vol., half bound, entitled "ANCIENT ARCHITECTURE," price 6s.
132. **THE ERECTION OF DWELLING-HOUSES**. Illustrated by a Perspective View, Plans, Elevations, and Sections of a pair of Semi-detached Villas, with the Specification, Quantities, and Estimates, &c. By S. H. BROOKS. New Edition, with Plates. 2s. 6d.
156. **QUANTITIES & MEASUREMENTS** in Bricklayers', Masons', Plasterers', Plumbers', Painters', Paperhangers', Gilders', Smiths', Carpenters' and Joiners' Work. By A. C. BEATON, Surveyor. Ninth Edition. 1s. 6d.
175. **LOCKWOOD'S BUILDER'S PRICE BOOK FOR 1893**. A Comprehensive Handbook of the Latest Prices and Data for Builders, Architects, Engineers, and Contractors. Re-constructed, Re-written, and further Enlarged. By FRANCIS T. W. MILLER, A.R.I.B.A. 700 pages. 8. 6d.; cloth boards, 4s. *[Just Published.]*
182. **CARPENTRY AND JOINERY—THE ELEMENTARY PRINCIPLES OF CARPENTRY**. Chiefly composed from the Standard Work of THOMAS TREGOLD, C.E. With a TREATISE ON JOINERY by E. WYNDHAM TARN, M.A. Fifth Edition, Revised. 3s. 6d.
- 182*. **CARPENTRY AND JOINERY. ATLAS** of 35 Plates to accompany the above. With Descriptive Letterpress. 4to 6s.
185. **THE COMPLETE MEASURER**; the Measurement of Boards, Glass, &c.; Unequal-sided, Square-sided, Octagonal-sided, Round Timber and Stone, and Standing Timber, &c. By RICHARD HORTON. Fifth Edition. 4s.; strongly bound in leather, 5s.
187. **HINTS TO YOUNG ARCHITECTS**. By G. WIGHTWICK. New Edition. By G. H. GUILLAUME. Illustrated. 3s. 6d.
188. **HOUSE PAINTING, GRAINING, MARBLING, AND SIGN WRITING**; with a Course of Elementary Drawing for House-Painters, Sign-Writers, &c., and a Collection of Useful Receipts. By ELLIS A. DAVIDSON. Sixth Edition. With Coloured Plates. 5s. cloth limp; 6s. cloth boards.
189. **THE RUDIMENTS OF PRACTICAL BRICKLAYING**. In Six Sections: General Principles; Arch Drawing, Cutting, and Setting; Pointing; Paving, Tiling, Materials; Slating and Plastering; Practical Geometry, Mensuration, &c. By ADAM HAMMOND. Seventh Edition. 1s. 6d.
191. **PLUMBING**. A Text-Book to the Practice of the Art or Craft of the Plumber. With Chapters upon House Drainage and Ventilation. Sixth Edition. With 380 Illustrations. By W. P. BUCHAN. 3s. 6d.
192. **THE TIMBER IMPORTER'S, TIMBER MERCHANT'S, AND BUILDER'S STANDARD GUIDE**. By R. E. GRANDY. 2s.
206. **A BOOK ON BUILDING, Civil and Ecclesiastical**, including CHURCH RESTORATION. With the Theory of Domes and the Great Pyramid, &c. By Sir EDMUND BECKETT, Bart., LL.D., Q.C., F.R.A.S. 4s. 6d.
225. **THE JOINTS MADE AND USED BY BUILDERS** in the Construction of various kinds of Engineering and Architectural Works. By WYVILL J. CHRISTY, Architect. With upwards of 160 Engravings on Wood. 3s.
228. **THE CONSTRUCTION OF ROOFS OF WOOD AND IRON**. By E. WYNDHAM TARN, M.A., Architect. Second Edition, revised. 1s. 6d.


* The † indicates that these vols. may be had strongly bound at 6d. extra.

Architecture, Building, etc., continued.

229. **ELEMENTARY DECORATION:** as applied to the Interior and Exterior Decoration of Dwelling-Houses, &c. By J. W. FACEY. 2s.
157. **PRACTICAL HOUSE DECORATION.** A Guide to the Art of Ornamental Painting. By JAMES W. FACEY. 2s. 6d.
- *.° *The two preceding Works, in One handsome Vol., half-bound, entitled "HOUSE DECORATION, ELEMENTARY AND PRACTICAL," price 5s.*
230. **A PRACTICAL TREATISE ON HANDRAILING.** Showing New and Simple Methods. By G. COLLINGS. Second Edition, Revised, including A TREATISE ON STAIRBUILDING. Plates. 2s. 6d.
247. **BUILDING ESTATES:** a Rudimentary Treatise on the Development, Sale, Purchase, and General Management of Building Land. By FOWLER MAITLAND, Surveyor. Second Edition, revised. 2s.
248. **PORTLAND CEMENT FOR USERS.** By HENRY FAIJA, Assoc. M. Inst. C.E. Third Edition, corrected. Illustrated. 2s.
152. **BRICKWORK:** a Practical Treatise, embodying the General and Higher Principles of Bricklaying, Cutting and Setting, &c. By F. WALKER. Third Edition, Revised and Enlarged. 1s. 6d.
23. **THE PRACTICAL BRICK AND TILE BOOK.** Comprising:
 280. BRICK AND TILE MAKING, by E. DOBSON, A.I.C.E.; PRACTICAL BRICKLAY-
 265. ING, by A. H. MMOND; BRICKCUTTING AND SETTING, by A. HAMMOND. 534 pp. with 270 Illustrations. 6s. Strongly half-bound.
253. **THE TIMBER MERCHANT'S, SAW-MILLER'S, AND IMPORTER'S FREIGHT-BOOK AND ASSISTANT.** By Wm. RICHARDSON. With Additions by M. POWIS BALE, A.M. Inst. C.E. 3s. 4
258. **CIRCULAR WORK IN CARPENTRY AND JOINERY.** A Practical Treatise on Circular Work of Single and Double Curvature. By GEORGE COLLINGS. Second Edition, 2s. 6d.
259. **GAS FITTING:** A Practical Handbook treating of every Description of Gas Laying and Fitting. By JOHN BLACK. 2s. 6d. 4
261. **SHORING AND ITS APPLICATION:** A Handbook for the Use of Students. By GEORGE H. BLAGROVE. 1s. 6d.
265. **THE ART OF PRACTICAL BRICK CUTTING & SETTING.** By ADAM HAMMOND. With 90 Engravings. 1s. 6d.
267. **THE SCIENCE OF BUILDING:** An Elementary Treatise on the Principles of Construction. By E. WYNDHAM TARN, M.A. Lond. Third Edition, Revised and Enlarged. 3s. 6d. 4
271. **VENTILATION:** a Text-book to the Practice of the Art of Ventilating Buildings. By W. P. BUCHAN, R.P., Sanitary Engineer, Author of "Plumbing," &c. 3s. 6d. 4
272. **ROOF CARPENTRY;** Practical Lessons in the Framing of Wood Roofs. For the Use of Working Carpenters. By GEO. COLLINGS, Author of "Handrailing and Stairbuilding," &c. 2s. [*Just published.*]
273. **THE PRACTICAL PLASTERER:** A Compendium of Plain and Ornamental Plaster Work. By WILFRED KEMP. 2s. [*Just published.*]

SHIPBUILDING, NAVIGATION, ETC.

51. **NAVAL ARCHITECTURE.** An Exposition of the Elementary Principles. By J. PRAKE. Fifth Edition, with Plates. 3s. 6d. 4
- 53°. **SHIPS FOR OCEAN & RIVER SERVICE,** Elementary and Practical Principles of the Construction of. By H. A. SOMMERFELDT. 1s. 6d.
- 53°. **AN ATLAS OF ENGRAVINGS** to illustrate the above. Twelve large folding plates. Royal 4to, cloth. 7s. 6d.
54. **MASTING, MAST-MAKING, AND RIGGING OF SHIPS,** Also Tables of Spars, Rigging, Blocks; Chain, Wire, and Hemp Ropes &c., relative to every class of vessels. By ROBERT KIPPING, N.A. 2s. 4

 *The 4 indicates that these vols. may be had strongly bound at 6d. extra.*

LONDON: CROSEY LOCKWOOD AND SON,

Shipbuilding, Navigation, Marine Engineering, etc., *cont.*

- 54*. **IRON SHIP-BUILDING.** With Practical Examples and Details.
By JOHN GRANTHAM, C.E. Fifth Edition. 4s.
55. **THE SAILOR'S SEA BOOK:** a Rudimentary Treatise on Navigation. By JAMES GREENWOOD, B.A. With numerous Woodcuts and Coloured Plates. New and enlarged edition. By W. H. ROSSER. 2s. 6d.‡
80. **MARINE ENGINES AND STEAM VESSELS.** By ROBERT MURRAY, C.E. Eighth Edition, thoroughly Revised, with Additions by the Author and by GEORGE CARLISLE, C.E. 4s. 6d. limp; 5s. cloth boards.
- 83*bis*. **THE FORMS OF SHIPS AND BOATS.** By W. BLAND. Eighth Edition, Revised, with numerous Illustrations and Models. 1s. 6d.
99. **NAVIGATION AND NAUTICAL ASTRONOMY,** in Theory and Practice. By Prof. J. R. YOUNG. New Edition. 2s. 6d.
106. **SHIPS' ANCHORS,** a Treatise on. By G. COTSELL, N.A. 1s. 6d.
149. **SAILS AND SAIL-MAKING.** With Draughting, and the Centre of Effort of the Sails; Weights and Sizes of Ropes; Mastng, Riggng, and Sails of Steam Vessels, &c. 12th Edition. By R. KIPPING, N.A. 2s. 6d.‡
155. **ENGINEER'S GUIDE TO THE ROYAL & MERCANTILE NAVIES.** By a PRACTICAL ENGINEER. Revised by D. F. MCCARTHY. 3s.
55. **PRACTICAL NAVIGATION.** Consisting of The Sailor's Sea-Book. By JAMES GREENWOOD and W. H. ROSSER. Together with the requisite Mathematical and Nautical Tables for the Working of the Problems. By H. LAW, C.E., and Prof. J. R. YOUNG. 7s. Half-bound.
- 204.

AGRICULTURE, GARDENING, ETC.

- 61*. **A COMPLETE READY RECKONER FOR THE ADMEASUREMENT OF LAND,** &c. By A. ARMAN. Third Edition, revised and extended by C. NORRIS, Surveyor, Valuer, &c. 2s.
131. **MILLER'S, CORN MERCHANT'S, AND FARMER'S READY RECKONER.** Second Edition, with a Price List of Modern Flour-Mill Machinery, by W. S. HUTTON, C.E. 2s.
140. **SOILS, MANURES, AND CROPS.** (Vol. 1. OUTLINES OF MODERN FARMING.) By R. SCOTT BURN. Woodcuts. 2s.
141. **FARMING & FARMING ECONOMY,** Notes, Historical and Practical, on. (Vol. 2. OUTLINES OF MODERN FARMING.) By R. SCOTT BURN. 3s.
142. **STOCK; CATTLE, SHEEP, AND HORSES.** (Vol. 3. OUTLINES OF MODERN FARMING.) By R. SCOTT BURN. Woodcuts. 2s. 6d.
145. **DAIRY, PIGS, AND POULTRY,** Management of the. By R. SCOTT BURN. (Vol. 4. OUTLINES OF MODERN FARMING.) 2s.
146. **UTILIZATION OF SEWAGE, IRRIGATION, AND RECLAMATION OF WASTE LAND.** (Vol. 5. OUTLINES OF MODERN FARMING.) By R. SCOTT BURN. Woodcuts. 2s. 6d.
- *. Nos. 140-1-2-5-6, in One Vol., handsomely half-bound, entitled "OUTLINES OF MODERN FARMING." By ROBERT SCOTT BURN. Price 12s.
177. **FRUIT TREES,** The Scientific and Profitable Culture of. From the French of DU BREUIL. Revised by GEO. GLENNY. 187 Woodcuts. 3s. 6d.
198. **SHEEP; THE HISTORY, STRUCTURE, ECONOMY, AND DISEASES OF.** By W. C. SPOONER, M.R.V.C., &c. Fifth Edition, enlarged, including Specimens of New and Improved Breeds. 3s. 6d.‡
201. **KITCHEN GARDENING MADE EASY.** By GEORGE M. F. GLENNY. Illustrated. 1s. 6d.‡
207. **OUTLINES OF FARM MANAGEMENT, and the Organization of Farm Labour.** By R. SCOTT BURN. 2s. 6d.‡
208. **OUTLINES OF LANDED ESTATES MANAGEMENT.** By R. SCOTT BURN. 2s. 6d.
- *. Nos. 207 & 208 in One Vol., handsomely half-bound, entitled "OUTLINES OF LANDED ESTATES AND FARM MANAGEMENT." By R. SCOTT BURN. Price 6s.

§ The ‡ indicates that these vols. may be had strongly bound at 6d. extra.

Agriculture, Gardening, etc., continued.

209. **THE TREE PLANTER AND PLANT PROPAGATOR.** A Practical Manual on the Propagation of Forest Trees, Fruit Trees, Flowering Shrubs, Flowering Plants, &c. By SAMUEL WOOD. 2s.
210. **THE TREE PRUNER.** A Practical Manual on the Pruning of Fruit Trees, including also their Training and Renovation; also the Pruning of Shrubs, Climbers, and Flowering Plants. By SAMUEL WOOD. 1s. 6d.
- * Nos. 209 & 210 in *One Vol., handsomely half-bound, entitled "THE TREE PLANTER, PROPAGATOR, AND PRUNER."* By SAMUEL WOOD. Price 3s. 6d.
218. **THE HAY AND STRAW MEASURER:** Being New Tables for the Use of Auctioneers, Valuers, Farmers, Hay and Straw Dealers, &c. By JOHN STEELE. Fifth Edition. 2s.
222. **SUBURBAN FARMING.** The Laying-out and Cultivation of Farms, adapted to the Produce of Milk, Butter, and Cheese, Eggs, Poultry, and Pigs. By Prof. JOHN DONALDSON and R. SCOTT BURN. 3s. 6d.†
231. **THE ART OF GRAFTING AND BUDDING.** By CHARLES BALLET. With Illustrations. 2s. 6d.†
232. **COTTAGE GARDENING;** or, Flowers, Fruits, and Vegetables for Small Gardens. By E. HOBDAY. 1s. 6d.
233. **GARDEN RECEIPTS.** Edited by CHARLES W. QUIN. 1s. 6d.
234. **MARKET AND KITCHEN GARDENING.** By C. W. SHAW, late Editor of "Gardening Illustrated." 3s.†
239. **DRAINING AND EMBANKING.** A Practical Treatise, embodying the most recent experience in the Application of Improved Methods. By JOHN SCOTT, late Professor of Agriculture and Rural Economy at the Royal Agricultural College, Cirencester. With 68 Illustrations. 1s. 6d.
240. **IRRIGATION AND WATER SUPPLY.** A Treatise on Water Meadows, Sewage Irrigation, and Warping; the Construction of Wells, Ponds, and Reservoirs, &c. By Prof. JOHN SCOTT. With 34 Illus. 1s. 6d.
241. **FARM ROADS, FENCES, AND GATES.** A Practical Treatise on the Roads, Tramways, and Waterways of the Farm; the Principles of Enclosures; and the different kinds of Fences, Gates, and Stiles. By Professor JOHN SCOTT. With 75 Illustrations. 1s. 6d.
242. **FARM BUILDINGS.** A Practical Treatise on the Buildings necessary for various kinds of Farms, their Arrangement and Construction, with Plans and Estimates. By Prof. JOHN SCOTT. With 105 Illus. 2s.
243. **BARN IMPLEMENTS AND MACHINES.** A Practical Treatise on the Application of Power to the Operations of Agriculture; and on various Machines used in the Threshing-barn, in the Stock-yard, and in the Dairy, &c. By Prof. J. SCOTT. With 123 Illustrations. 2s.
244. **FIELD IMPLEMENTS AND MACHINES.** A Practical Treatise on the Varieties now in use, with Principles and Details of Construction, their Points of Excellence, and Management. By Professor JOHN SCOTT. With 138 Illustrations. 2s.
245. **AGRICULTURAL SURVEYING.** A Practical Treatise on Land Surveying, Levelling, and Setting-out; and on Measuring and Estimating Quantities, Weights, and Values of Materials, Produce, Stock, &c. By Prof. JOHN SCOTT. With 62 Illustrations. 1s. 6d.
- * Nos. 239 to 245 in *One Vol., handsomely half-bound, entitled "THE COMPLETE TEXT-BOOK OF FARM ENGINEERING."* By Professor JOHN SCOTT. Price 12s.
250. **MEAT PRODUCTION.** A Manual for Producers, Distributors, &c. By JOHN EWART. 2s. 6d.†
266. **BOOK-KEEPING FOR FARMERS & ESTATE OWNERS.** By J. M. WOODMAN, Chartered Accountant. 2s. 6d. cloth limp; 3s. 6d. cloth boards.

 The † indicates that these vols. may be had strongly bound at 6d. extra.

MATHEMATICS, ARITHMETIC, ETC.

32. **MATHEMATICAL INSTRUMENTS**, a Treatise on; Their Construction, Adjustment, Testing, and Use concisely Explained. By J. F. HEATHER, M.A. Fourteenth Edition, revised, with additions, by A. T. WALMSLEY, M.I.C.E., Fellow of the Surveyors' Institution. Original Edition, in 1 vol., Illustrated. 2s.4
- *.* In ordering the above, be careful to say, "Original Edition" (No. 32), to distinguish it from the Enlarged Edition in 3 vols. (Nos. 168-9-70.)
76. **DESCRIPTIVE GEOMETRY**, an Elementary Treatise on; with a Theory of Shadows and of Perspective, extracted from the French of G. MONGE. To which is added, a description of the Principles and Practice of Isometrical Projection. By J. F. HEATHER, M.A. With 14 Plates. 2s.
178. **PRACTICAL PLANE GEOMETRY**: giving the Simplest Modes of Constructing Figures contained in one Plane and Geometrical Construction of the Ground. By J. F. HEATHER, M.A. With 215 Woodcuts. 2s.
83. **COMMERCIAL BOOK-KEEPING**. With Commercial Phrases and Forms in English, French, Italian, and German. By JAMES HADDON, M.A., Arithmetical Master of King's College School, London. 1s. 6d.
84. **ARITHMETIC**, a Rudimentary Treatise on: with full Explanations of its Theoretical Principles, and numerous Examples for Practice. By Professor J. R. YOUNG. Eleventh Edition. 1s. 6d.
- 84*. A Key to the above, containing Solutions in full to the Exercises, together with Comments, Explanations, and Improved Processes, for the Use of Teachers and Unassisted Learners. By J. R. YOUNG. 1s. 6d.
85. **EQUATIONAL ARITHMETIC**, applied to Questions of Interest, Annuities, Life Assurance, and General Commerce; with various Tables by which all Calculations may be greatly facilitated. By W. HIFSLY. 2s.
86. **ALGEBRA**, the Elements of. By JAMES HADDON, M.A. With Appendix, containing miscellaneous Investigations, and a Collection of Problems in various parts of Algebra. 2s.
- 86*. A KEY and COMPANION to the above Book, forming an extensive repository of Solved Examples and Problems in Illustration of the various Expedients necessary in Algebraical Operations. By J. R. YOUNG. 1s. 6d.
88. **EUCLID, THE ELEMENTS OF**: with many additional Propositions
89. and Explanatory Notes: to which is prefixed, an Introductory Essay on Logic. By HENRY LAW, C.E. 2s. 6d.†
- *.* Sold also separately, viz. —
88. EUCLID, The First Three Books. By HENRY LAW, C.E. 1s. 6d.
89. EUCLID, Books 4, 5, 6, 11, 12. By HENRY LAW, C.E. 1s. 6d.
90. **ANALYTICAL GEOMETRY AND CONIC SECTIONS** By JAMES HANN. A New Edition, by Professor J. R. YOUNG. 2s.4
91. **PLANE TRIGONOMETRY**, the Elements of. By JAMES HANN, formerly Mathematical Master of King's College, London. 1s. 6d.
92. **SPHERICAL TRIGONOMETRY**, the Elements of. By JAMES HANN. Revised by CHARLES H. DOWLING, C.E. 1s.
- *.* Or with "The Elements of Plane Trigonometry," in One Volume, 2s. 6d.
93. **MENSURATION AND MEASURING**. With the Mensuration and Levelling of Land for the Purposes of Modern Engineering. By T. BAKER, C.E. New Edition by E. NUGENT, C.E. Illustrated. 1s. 6d.
101. **DIFFERENTIAL CALCULUS**, Elements of the. By W. S. B. WOOLHOUSE, F.R.A.S., &c. 1s. 6d.
102. **INTEGRAL CALCULUS**, Rudimentary Treatise on the. By HOMERSHAM COX, B.A. Illustrated. 1s.
136. **ARITHMETIC**, Rudimentary, for the Use of Schools and Self-Instruction. By JAMES HADDON, M.A. Revised by A. ARMAN. 1s. 6d.
137. A KEY to HADDON'S RUDIMENTARY ARITHMETIC. By A. ARMAN. 1s. 6d.

† The † indicates that these vols. may be had strongly bound at 6d. extra.

Mathematics, Arithmetic, etc., *continued.*

168. **DRAWING AND MEASURING INSTRUMENTS.** Including—I. Instruments employed in Geometrical and Mechanical Drawing, and in the Construction, Copying, and Measurement of Maps and Plans. II. Instruments used for the purposes of Accurate Measurement, and for Arithmetical Computations. By J. F. HEATHER, M.A. Illustrated. 1s. 6d.
169. **OPTICAL INSTRUMENTS.** Including (more especially) Telescopes, Microscopes, and Apparatus for producing copies of Maps and Plans by Photography. By J. F. HEATHER, M.A. Illustrated. 1s. 6d.
170. **SURVEYING AND ASTRONOMICAL INSTRUMENTS.** Including—I. Instruments Used for Determining the Geometrical Features of a portion of Ground. II. Instruments Employed in Astronomical Observations. By J. F. HEATHER, M.A. Illustrated. 1s. 6d.
- * *The above three volumes form an enlargement of the Author's original work, "Mathematical Instruments." (See No. 32 in the Series.).*
168. } **MATHEMATICAL INSTRUMENTS.** By J. F. HEATHER,
169. } M.A. Enlarged Edition, for the most part entirely re-written. The 3 Parts as
170. } above, in One thick Volume. With numerous Illustrations. 4s. 6d.†
158. **THE SLIDE RULE, AND HOW TO USE IT;** containing full, easy, and simple Instructions to perform all Business Calculations with unexampled rapidity and accuracy. By CHARLES HOARE, C.E. Sixth Edition. With a Slide Rule in tuck of cover. 2s. 6d.†
196. **THEORY OF COMPOUND INTEREST AND ANNUITIES;** with Tables of Logarithms for the more Difficult Computations of Interest, Discount, Annuities, &c. By FEDOR THOMAN. Fourth Edition. 4s.†
199. **THE COMPENDIOUS CALCULATOR;** or, Easy and Concise Methods of Performing the various Arithmetical Operations required in Commercial and Business Transactions; together with Useful Tables. By D. O'GORMAN. Twenty-seventh Edition, carefully revised by C. NORRIS. 2s. 6d., cloth limp; 3s. 6d., strongly half-bound in leather.
204. **MATHEMATICAL TABLES,** for Trigonometrical, Astronomical, and Nautical Calculations; to which is prefixed a Treatise on Logarithms. By HENRY LAW, C.E. Together with a Series of Tables for Navigation and Nautical Astronomy. By Prof. J. R. YOUNG. New Edition. 4s.
- 204*. **LOGARITHMS.** With Mathematical Tables for Trigonometrical, Astronomical, and Nautical Calculations. By HENRY LAW, M.Inst.C.E. New and Revised Edition. (Forming part of the above Work). 3s.
221. **MEASURES, WEIGHTS, AND MONEYS OF ALL NATIONS,** and an Analysis of the Christian, Hebrew, and Mahometan Calendars. By W. S. B. WOOLHOUSE, F.R.A.S., F.S.S. Seventh Edition. 2s. 6d.†
227. **MATHEMATICS AS APPLIED TO THE CONSTRUCTIVE ARTS.** Illustrating the various processes of Mathematical Investigation, by means of Arithmetical and Simple Algebraical Equations and Practical Examples. By FRANCIS CAMPIN, C.E. Second Edition. 3s.†

PHYSICAL SCIENCE, NATURAL PHILOSOPHY, ETC.

1. **CHEMISTRY.** By Professor GEORGE FOWNES, F.R.S. With an Appendix on the Application of Chemistry to Agriculture. 1s.
2. **NATURAL PHILOSOPHY,** Introduction to the Study of. By C. TOMLINSON. Woodcuts. 1s. 6d.
6. **MECHANICS,** Rudimentary Treatise on. By CHARLES TOMLINSON. Illustrated. 1s. 6d.
7. **ELECTRICITY;** showing the General Principles of Electrical Science, and the purposes to which it has been applied. By Sir W. SNOW HARRIS, F.R.S., &c. With Additions by R. SABINE, C.E., F.S.A. 1s. 6d.
- 7*. **GALVANISM.** By Sir W. SNOW HARRIS. New Edition by ROBERT SABINE, C.E., F.S.A. 1s. 6d.
8. **MAGNETISM;** being a concise Exposition of the General Principles of Magnetical Science. By Sir W. SNOW HARRIS. New Edition, revised by H. M. NOAD, Ph.D. With 165 Woodcuts. 3s. 6d.†

† *The † indicates that these vols. may be had strongly bound at 6d. extra.*


LONDON: CROSBY LOCKWOOD AND SON,

Physical Science, Natural Philosophy, etc., continued.

11. **THE ELECTRIC TELEGRAPH**; its History and Progress; with Descriptions of some of the Apparatus. By R. SABINE, C.E., F.S.A. 3s.
12. **PNEUMATICS**, including Acoustics and the Phenomena of Wind Currents, for the Use of Beginners By CHARLES TOMLINSON, F.R.S. Fourth Edition, enlarged. Illustrated. 1s. 6d.
12. **MANUAL OF THE MOLLUSCA**; a Treatise on Recent and Fossil Shells. By Dr. S. P. WOODWARD, A.L.S. Fourth Edition. With Plates and 300 Woodcuts. 7s. 6d., cloth.
96. **ASTRONOMY**. By the late Rev. ROBERT MAIN, M.A. Third Edition, by WILLIAM THYNNE LYNN, B.A., F.R.A.S. 2s.
97. **STATICS AND DYNAMICS**, the Principles and Practice of; embracing also a clear development of Hydrostatics, Hydrodynamics, and Central Forces. By T. BAKER, C.E. Fourth Edition. 1s. 6d.
173. **PHYSICAL GEOLOGY**, partly based on Major-General PORTLOCK's "Rudiments of Geology." By RALPH TATE, A.L.S., &c. Woodcuts. 2s.
174. **HISTORICAL GEOLOGY**, partly based on Major-General PORTLOCK's "Rudiments." By RALPH TATE, A.L.S., &c. Woodcuts. 2s. 6d.
173. **RUDIMENTARY TREATISE ON GEOLOGY**, Physical and Historical. Partly based on Major-General PORTLOCK's "Rudiments of Geology." By RALPH TATE, A.L.S., F.G.S., &c. In One Volume. 4s. 6d.
183. **ANIMAL PHYSICS**, Handbook of. By Dr. LARDNER, D.C.L., & formerly Professor of Natural Philosophy and Astronomy in University College, Lond. With 520 Illustrations. In One Vol. 7s. 6d., cloth boards.
184. **ANIMAL PHYSICS**. By Dr. LARDNER. Part I., Chapters I.—VII. 4s.
184. **ANIMAL PHYSICS**. By Dr. LARDNER. Part II., Chapters VIII.—XVIII. 3s.
269. **LIGHT**: an Introduction to the Science of Optics, for the Use of Students of Architecture, Engineering, and other Applied Sciences. By E. WYNDHAM TARN, M.A. 1s. 6d. [*Just published.*]

FINE ARTS.

20. **PERSPECTIVE FOR BEGINNERS**. Adapted to Young Students and Amateurs in Architecture, Painting, &c. By GEORGE PYNE. 2s.
40. **GLASS STAINING, AND THE ART OF PAINTING ON GLASS**. From the German of Dr. GRESERT and EMANUEL OTTO FROMBERG. With an Appendix on THE ART OF ENAMELLING. 2s. 6d.
69. **MUSIC**, A Rudimentary and Practical Treatise on. With numerous Examples. By CHARLES CHILD SPENCER. 2s. 6d.
71. **PIANOFORTE**, The Art of Playing the. With numerous Exercises & Lessons from the Best Masters. By CHARLES CHILD SPENCER. 1s. 6d.
- 67-71. **MUSIC & THE PIANOFORTE**. In one vol. Half bound, 5s.
181. **PAINTING POPULARLY EXPLAINED**, including Fresco, Oil, Mosaic, Water Colour, Water-Glass, Tempera, Encaustic, Miniature, Painting on Ivory, Vellum, Pottery, Enamel, Glass, &c. With Historical Sketches of the Progress of the Art by THOMAS JOHN GULLICK, assisted by JOHN IMBS, F.S.A. Sixth Edition, revised and enlarged. 5s.
186. **A GRAMMAR OF COLOURING**, applied to Decorative Painting and the Arts. By GEORGE FIELD. New Edition, enlarged and adapted to the Use of the Ornamental Painter and Designer. By ELLIS A. DAVIDSON. With two new Coloured Diagrams, &c. 3s.
246. **A DICTIONARY OF PAINTERS, AND HANDBOOK FOR PICTURE AMATEURS**; including Methods of Painting, Cleaning, Relining and Restoring, Schools of Painting, &c. With Notes on the Copyists and Imitators of each Master. By PHILIPPE DARYL. 2s. 6d.

 The † indicates that these vols. may be had strongly bound at 6d. extra.

7, STATIONERS' HALL COURT, LUDGATE HILL, E.C.

INDUSTRIAL AND USEFUL ARTS.

23. **BRICKS AND TILES**, Rudimentary Treatise on the Manufacture of. By E. DOBSON, M.R.I.B.A. Illustrated, 3s.†
67. **CLOCKS, WATCHES, AND BELLS**, a Rudimentary Treatise on. By Sir EDMUND BECKETT, LL.D., Q.C. Seventh Edition, revised and enlarged. 4s. 6d. limp; 5s. 6d. cloth boards.
- 83*^o. **CONSTRUCTION OF DOOR LOCKS**. Compiled from the Papers of A. C. HOBBS, and Edited by CHARLES TOMLINSON, F.R.S. 2s. 6d.
162. **THE BRASS FOUNDER'S MANUAL**; Instructions for Modelling, Pattern-Making, Moulding, Turning, Filing, Burnishing, Bronzing, &c. With copious Receipts, &c. By WALTER GRAHAM. 2s.†
205. **THE ART OF LETTER PAINTING MADE EASY**. By J. G. BADENOCH. Illustrated with 12 full-page Engravings of Examples. 1s. 6d.
215. **THE GOLDSMITH'S HANDBOOK**, containing full Instructions for the Alloying and Working of Gold. By GEORGE E. GEE, 3s.†
225. **THE SILVERSMITH'S HANDBOOK**, containing full Instructions for the Alloying and Working of Silver. By GEORGE E. GEE. 3s.†
- *^o. *The two preceding Works, in One handsome Vol., half-bound, entitled "THE GOLDSMITH'S & SILVERSMITH'S COMPLETE HANDBOOK," 7s.*
240. **THE HALL-MARKING OF JEWELLERY PRACTICALLY CONSIDERED**. By GEORGE E. GEE. 3s.†
224. **COACH BUILDING**, A Practical Treatise, Historical and Descriptive. By J. W. BURGESS. 2s. 6d.†
235. **PRACTICAL ORGAN BUILDING**. By W. E. DICKSON, M.A., Precentor of Ely Cathedral. Illustrated. 2s. 6d.†
262. **THE ART OF BOOT AND SHOEMAKING**. By JOHN BEDFORD LENO. Numerous Illustrations. Third Edition. 2s.
263. **MECHANICAL DENTISTRY**: A Practical Treatise on the Construction of the Various Kinds of Artificial Dentures, with Formulae, Tables, Receipts, &c. By CHARLES HUNTER. Third Edition. 3s.†
270. **WOOD ENGRAVING**: A Practical and Easy Introduction to the Study of the Art. By W. N. BROWN. 1s. 6d.

MISCELLANEOUS VOLUMES.

36. **A DICTIONARY OF TERMS used in ARCHITECTURE, BUILDING, ENGINEERING, MINING, METALLURGY, ARCHÆOLOGY, the FINE ARTS, &c.** By JOHN WEALE. Sixth Edition. Revised by ROBERT HUNT, F.R.S. Illustrated. 5s. limp; 6s. cloth boards.
50. **LABOUR CONTRACTS**. A Popular Handbook on the Law of Contracts for Works and Services. By DAVID GIBBONS. Fourth Edition, Revised, with Appendix of Statutes by T. F. UTILEY, Solicitor, 3s. 6d. cloth.
112. **MANUAL OF DOMESTIC MEDICINE**. By R. GOODING, B.A., M.D. A Family Guide in all Cases of Accident and Emergency 2s.
- 112*^o. **MANAGEMENT OF HEALTH**. A Manual of Home and Personal Hygiene. By the Rev. JAMES BAIRD, B.A. 1s.
150. **LOGIC**, Pure and Applied. By S. H. EMMENS. 1s. 6d.
153. **SELECTIONS FROM LOCKE'S ESSAYS ON THE HUMAN UNDERSTANDING**. With Notes by S. H. EMMENS. 2s.
154. **GENERAL HINTS TO EMIGRANTS**. 2s.
157. **THE EMIGRANT'S GUIDE TO NATAL**. By R. MANN. 2s.
193. **HANDBOOK OF FIELD FORTIFICATION**. By Major W. W. KNOLLYS, F.R.G.S. With 163 Woodcuts. 3s.†
194. **THE HOUSE MANAGER**: Being a Guide to Housekeeping. Practical Cookery, Pickling and Preserving, Household Work, Dairy Management, &c. By AN OLD HOUSEKEEPER. 3s. 6d.†
194. **HOUSE BOOK (The)**. Comprising:—I. THE HOUSE MANAGER. 112 & By an OLD HOUSEKEEPER. II. DOMESTIC MEDICINE. By R. GOODING, M.D.
- 112*^o. III. MANAGEMENT OF HEALTH. By J. BAIRD. In One Vol., half-bound, 6s.

 *The † indicates that these vols may be had strongly bound at 6d. extra.*

LONDON: CROSBY LOCKWOOD AND SON.

EDUCATIONAL AND CLASSICAL SERIES.

HISTORY.

1. **England, Outlines of the History of;** more especially with reference to the Origin and Progress of the English Constitution. By WILLIAM DOUGLAS HAMILTON, F.S.A., of Her Majesty's Public Record Office. 4th Edition, revised. 5s.; cloth boards, 6s.
5. **Greece, Outlines of the History of;** in connection with the Rise of the Arts and Civilization in Europe. By W. DOUGLAS HAMILTON, of University College, London, and EDWARD LEVIEN, M.A., of Balliol College, Oxford. 2s. 6d.; cloth boards, 3s. 6d.
7. **Rome, Outlines of the History of;** from the Earliest Period to the Christian Era and the Commencement of the Decline of the Empire. By EDWARD LEVIEN, of Balliol College, Oxford. Map, 2s. 6d.; cl. bds. 3s. 6d.
9. **Chronology of History, Art, Literature, and Progress,** from the Creation of the World to the Present Time. The Continuation by W. D. HAMILTON, F.S.A. 3s.; cloth boards, 3s. 6d.
50. **Dates and Events in English History,** for the use of Candidates in Public and Private Examinations. By the Rev. E. RAND. 1s

ENGLISH LANGUAGE AND MISCELLANEOUS.

11. **Grammar of the English Tongue, Spoken and Written.** With an Introduction to the Study of Comparative Philology. By HYDE CLARKE, D.C.L. Fifth Edition. 1s. 6d.
12. **Dictionary of the English Language, as Spoken and Written.** Containing above 100,000 Words. By HYDE CLARKE, D.C.L. 3s. 6d.; cloth boards, 4s. 6d.; complete with the GRAMMAR, cloth bds., 5s. 6d.
48. **Composition and Punctuation, familiarly Explained** for those who have neglected the Study of Grammar. By JUSTIN BRENNAN. 18th Edition. 1s. 6d.
49. **Derivative Spelling-Book:** Giving the Origin of Every Word from the Greek, Latin, Saxon, German, Teutonic, Dutch, French, Spanish, and other Languages; with their present Acceptation and Pronunciation. By J. ROWBOTHAM, F.R.A.S. Improved Edition. 1s. 6d.
51. **The Art of Extempore Speaking:** Hints for the Pulpit, the Senate, and the Bar. By M. BAUTAIN, Vicar-General and Professor at the Sorbonne. Translated from the French. 8th Edition, carefully corrected. 2s. 6d.
54. **Analytical Chemistry, Qualitative and Quantitative,** a Course of. To which is prefixed, a Brief Treatise upon Modern Chemical Nomenclature and Notation. By WM. W. PINK and GEORGE E. WEBSTER. 2s.

THE SCHOOL MANAGERS' SERIES OF READING BOOKS,

Edited by the Rev. A. R. GRANT, Rector of Hitcham, and Honorary Canon of Ely; formerly H.M. Inspector of Schools.
INTRODUCTORY PRIMER, 3d.

	s.	d.		s.	d.
FIRST STANDARD . . .	0	6	FOURTH STANDARD . . .	1	2
SECOND " . . .	0	10	FIFTH " . . .	1	6
THIRD " . . .	1	0	SIXTH " . . .	1	6

LESSONS FROM THE BIBLE. Part I. Old Testament. 1s.

LESSONS FROM THE BIBLE. Part II. New Testament, to which is added THE GEOGRAPHY OF THE BIBLE, for very young Children. By Rev. C THORNTON FORSTER. 1s. 2d. *.* Or the Two Parts in One Volume. 2s.

FRENCH.

24. **French Grammar.** With Complete and Concise Rules on the Genders of French Nouns. By G. L. STRAUSS, Ph.D. 1s. 6d.
25. **French-English Dictionary.** Comprising a large number of New Terms used in Engineering, Mining, &c. By ALFRED ELWES. 1s. 6d.
26. **English-French Dictionary.** By ALFRED ELWES. 2s.
- 25, 26. **French Dictionary** (as above). Complete, in One Vol., 3s.; cloth boards, 3s. 6d. *.* Or with the GRAMMAR, cloth boards, 4s. 6d.]
47. **French and English Phrase Book:** containing Introductory Lessons, with Translations, several Vocabularies of Words, a Collection of suitable Phrases, and Easy Familiar Dialogues. 1s. 6d.

GERMAN.

39. **German Grammar.** Adapted for English Students, from Heyse's Theoretical and Practical Grammar, by Dr. G. L. STRAUSS. 1s. 6d.
40. **German Reader: A Series of Extracts,** carefully culled from the most approved Authors of Germany; with Notes, Philological and Explanatory. By G. L. STRAUSS, Ph.D. 1s.
- 41-43. **German Trilog Dictionary.** By N. E. S. A. HAMILTON. In Three Parts. Part I. German-French-English. Part II. English-German-French. Part III. French-German-English. 3s., or cloth boards, 4s.
- 41-43. **German Trilog Dictionary** (as above), together with German & 39. **Grammar** (No. 39), in One Volume, cloth boards, 5s.

ITALIAN.

27. **Italian Grammar,** arranged in Twenty Lessons, with a Course of Exercises. By ALFRED ELWES. 1s. 6d.
28. **Italian Trilog Dictionary,** wherein the Genders of all the Italian and French Nouns are carefully noted down. By ALFRED ELWES. Vol. I. Italian-English-French. 2s. 6d.
30. **Italian Trilog Dictionary.** By A. ELWES. Vol. 2. English-French-Italian. 2s. 6d.
32. **Italian Trilog Dictionary.** By ALFRED ELWES. Vol. 3. French-Italian-English. 2s. 6d.
- 28, 30, 32. **Italian Trilog Dictionary** (as above). In One Vol., 7s. 6d. Cloth boards.

SPANISH AND PORTUGUESE.

34. **Spanish Grammar,** in a Simple and Practical Form. With a Course of Exercises. By ALFRED ELWES. 1s. 6d.
35. **Spanish-English and English-Spanish Dictionary.** Including a large number of Technical Terms used in Mining, Engineering, &c. with the proper Accents and the Gender of every Noun. By ALFRED ELWES. 4s.; cloth boards, 5s. *.* Or with the GRAMMAR, cloth boards, 6s.
55. **Portuguese Grammar,** in a Simple and Practical Form. With a Course of Exercises. By ALFRED ELWES. 1s. 6d.
56. **Portuguese-English and English-Portuguese Dictionary.** Including a large number of Technical Terms used in Mining, Engineering, &c., with the proper Accents and the Gender of every Noun. By ALFRED ELWES. Second Edition, Revised, 5s.; cloth boards, 6s. *.* Or with the GRAMMAR, cloth boards, 7s.

HEBREW.

- 46*. **Hebrew Grammar.** By Dr. BRESSLAU. 1s. 6d.
44. **Hebrew and English Dictionary,** Biblical and Rabbinical; containing the Hebrew and Chaldee Roots of the Old Testament Post-Rabbinical Writings. By Dr. BRESSLAU. 6s.
46. **English and Hebrew Dictionary.** By Dr. BRESSLAU. 3s.
- 44, 46. **Hebrew Dictionary** (as above), in Two Vols., complete, with 46*. the GRAMMAR, cloth boards, 12s.

LONDON: CROSBY LOCKWOOD AND SON,

LATIN.

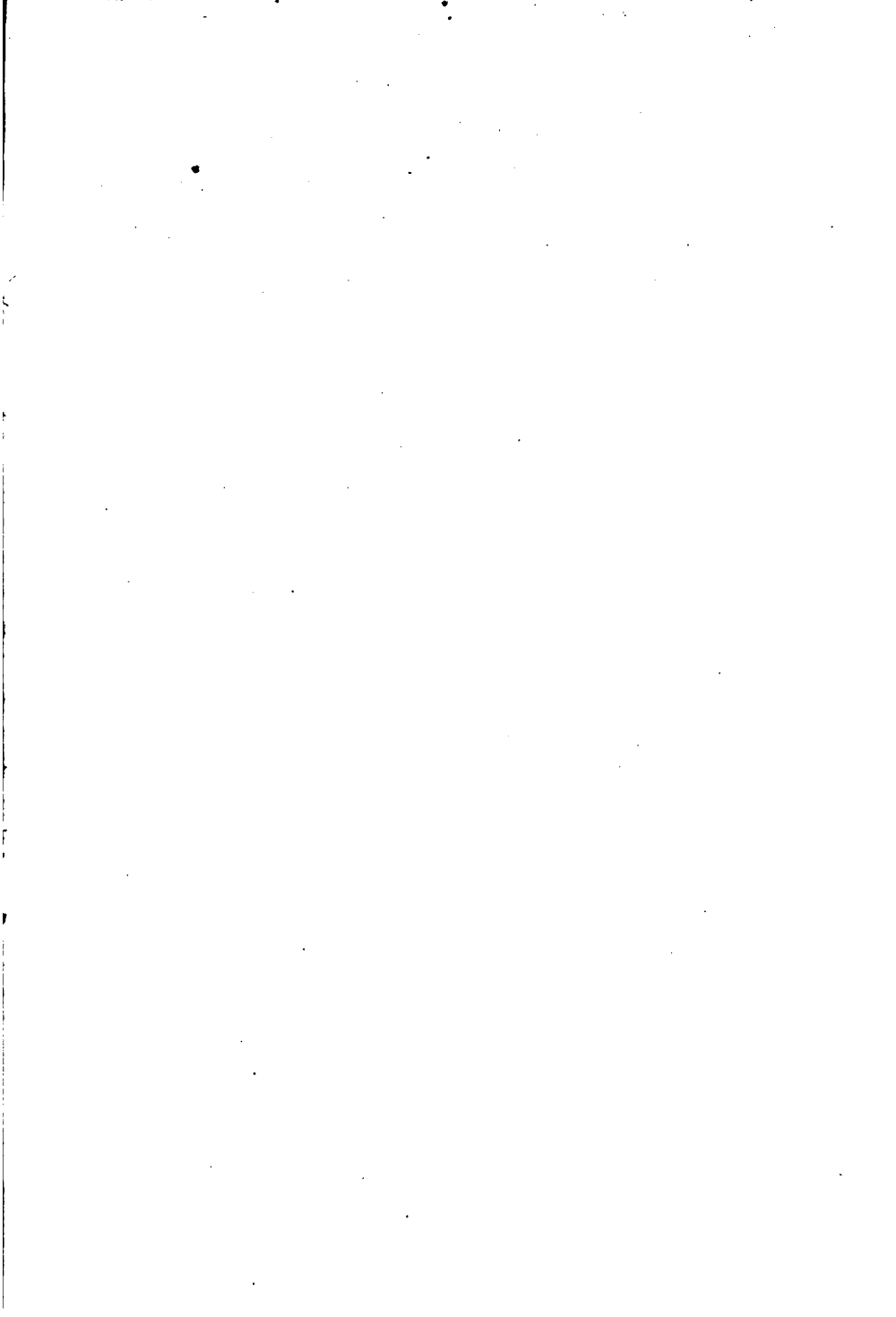
19. **Latin Grammar.** Containing the Inflections and Elementary Principles of Translation and Construction. By the Rev. THOMAS GOODWIN, M.A., Head Master of the Greenwich Proprietary School. 1s. 6d.
20. **Latin-English Dictionary.** By the Rev. THOMAS GOODWIN, M.A. 2s.
22. **English-Latin Dictionary;** together with an Appendix of French and Italian Words which have their origin from the Latin. By the Rev. THOMAS GOODWIN, M.A. 1s. 6d.
- 20, 22. **Latin Dictionary** (as above). Complete in One Vol., 3s. 6d. cloth boards, 4s. 6d. * * * Or with the GRAMMAR, cloth boards, 5s. 6d.
- LATIN CLASSICS.** With Explanatory Notes in English.
 1. **Latin Delectus.** Containing Extracts from Classical Authors, with Genealogical Vocabularies and Explanatory Notes, by H. YOUNG. 1s. 6d.
 2. **Cæsar's Commentarii de Bello Gallico.** Notes, and a Geographical Register for the Use of Schools, by H. YOUNG. 2s.
 3. **Cornelius Nepos.** With Notes. By H. YOUNG. 1s.
 4. **Virgilii Maronis Bucolica et Georgica.** With Notes on the Bucolics by W. RUSHTON, M.A., and on the Georgics by H. YOUNG. 1s. 6d.
 5. **Virgilii Maronis Æneis.** With Notes, Critical and Explanatory, by H. YOUNG. New Edition, revised and improved. With copious Additional Notes by Rev. T. H. L. LEARY, D.C.L., formerly Scholar of Brasenose College, Oxford. 3s.
- 5* ——— Part 1. Books i.—vi., 1s. 6d.
- 5* ——— Part 2. Books vii.—xii., 2s.
6. **Horace; Odes, Epode, and Carmen Sæculare.** Notes by H. YOUNG. 1s. 6d.
7. **Horace; Satires, Epistles, and Ars Poetica.** Notes by W. BROWN-RIGG SMITH, M.A., F.R.G.S. 1s. 6d.
8. **Sallustii Crispi Catalina et Bellum Jugurthinum.** Notes, Critical and Explanatory, by W. M. DONNE, B.A., Trin. Coll., Cam. 1s. 6d.
9. **Terentii Andria et Heautontimorumenos.** With Notes, Critical and Explanatory, by the Rev. JAMES DAVIES, M.A. 1s. 6d.
10. **Terentii Adelphi, Hecyra, Phormio.** Edited, with Notes, Critical and Explanatory, by the Rev. JAMES DAVIES, M.A. 2s.
11. **Terentii Eunuchus, Comœdia.** Notes, by Rev. J. DAVIES, M.A. 1s. 6d.
12. **Ciceronis Oratio pro Sexto Roscio Amerino.** Edited, with an Introduction, Analysis, and Notes, Explanatory and Critical, by the Rev. JAMES DAVIES, M.A. 1s. 6d.
13. **Ciceronis Orationes in Catilinam, Verrem, et pro Archia.** With Introduction, Analysis, and Notes, Explanatory and Critical, by Rev. T. H. L. LEARY, D.C.L. formerly Scholar of Brasenose College, Oxford. 1s. 6d.
14. **Ciceronis Cato Major, Lælius Brutus, sive de Senectute, de Amicitia, de Claris Oratoribus Dialogi.** With Notes by W. BROWN-RIGG SMITH, M.A., F.R.G.S. 2s.
16. **Livy: History of Rome.** Notes by H. YOUNG and W. B. SMITH, M.A. Part 1. Books i., ii., 1s. 6d.
- 16* ——— Part 2. Books iii., iv., v., 1s. 6d.
17. ——— Part 3. Books xxi., xxii., 1s. 6d.
19. **Latin Verse Selections,** from Catullus, Tibullus, Propertius, and Ovid. Notes by W. B. DONNE, M.A., Trinity College, Cambridge. 2s.
20. **Latin Prose Selections,** from Varro, Columella, Vitruvius, Seneca, Quintilian, Florus, Velleius Paterculus, Valerius Maximus, Suetonius, Apuleius, &c. Notes by W. B. DONNE, M.A. 2s.
21. **Juvenalis Satiræ.** With Prolegomena and Notes by T. H. S. ESCOTT, B.A., Lecturer on Logic at King's College, London. 2s.

GREEK.

14. **Greek Grammar**, in accordance with the *Principles and Philological Researches* of the most eminent Scholars of our own day. By HANS CLAUDE HAMILTON. 1s. 6d.
- 15, 17. **Greek Lexicon**. Containing all the Words in General Use, with their Significations, Inflections, and Doubtful Quantities. By HENRY R. HAMILTON. Vol. 1. Greek-English, 2s. 6d.; Vol. 2. English-Greek, 2s. Or the Two Vols. in One, 4s. 6d.: cloth boards, 5s.
- 14, 15. **Greek Lexicon** (as above). Complete, with the **GRAMMAR**, in 17. One Vol., cloth boards, 6s.

GREEK CLASSICS. With Explanatory Notes in English.

1. **Greek Delectus**. Containing Extracts from Classical Authors, with Genealogical Vocabularies and Explanatory Notes, by H. YOUNG. New Edition, with an improved and enlarged Supplementary Vocabulary, by JOHN HUTCHISON, M.A., of the High School, Glasgow. 1s. 6d.
- 2, 3. **Xenophon's Anabasis; or, The Retreat of the Ten Thousand**. Notes and a Geographical Register, by H. YOUNG. Part 1. Books i. to iii., 1s. Part 2. Books iv. to vii., 1s.
4. **Lucian's Select Dialogues**. The Text carefully revised, with Grammatical and Explanatory Notes, by H. YOUNG. 1s. 6d.
- 5-12. **Homer, The Works of**. According to the Text of BAEUMLEIN. With Notes, Critical and Explanatory, drawn from the best and latest Authorities, with Preliminary Observations and Appendices, by T. H. L. LEARY, M.A., D.C.L.
- | | | |
|--------------|-------------------------------------|---|
| THE ILLAD: | Part 1. Books i. to vi., 1s. 6d. | Part 3. Books xiii. to xviii., 1s. 6d. |
| | Part 2. Books vii. to xii., 1s. 6d. | Part 4. Books xix. to xxiv., 1s. 6d. |
| THE ODYSSEY: | Part 1. Books i. to vi., 1s. 6d. | Part 3. Books xiii. to xviii., 1s. 6d. |
| | Part 2. Books vii. to xii., 1s. 6d. | Part 4. Books xix. to xxiv., and Hymns, 2s. |
13. **Plato's Dialogues: The Apology of Socrates, the Crito, and the Phædo**. From the Text of C. F. HERMANN. Edited with Notes, Critical and Explanatory, by the Rev. JAMES DAVIES, M.A. 2s.
- 14-17. **Herodotus, The History of**, chiefly after the Text of GAISFORD. With Preliminary Observations and Appendices, and Notes, Critical and Explanatory, by T. H. L. LEARY, M.A., D.C.L.
- | |
|---|
| Part 1. Books i., ii. (The Clio and Euterpe), 2s. |
| Part 2. Books iii., iv. (The Thalia and Melpomene), 2s. |
| Part 3. Books v.-vii. (The Terpsichore, Erato, and Polymnia), 2s. |
| Part 4. Books viii., ix. (The Urania and Calliope) and Index, 1s. 6d. |
18. **Sophocles: Œdipus Tyrannus**. Notes by H. YOUNG. 1s.
20. **Sophocles: Antigone**. From the Text of DINDORF. Notes, Critical and Explanatory, by the Rev. JOHN MILNER, B.A. 2s.
23. **Euripides: Hecuba and Medea**. Chiefly from the Text of DINDORF. With Notes, Critical and Explanatory, by W. BROWNRIEGG SMITH, M.A., F.R.G.S. 1s. 6d.
26. **Euripides: Alceſtis**. Chiefly from the Text of DINDORF. With Notes, Critical and Explanatory, by JOHN MILNER, B.A. 1s. 6d.
30. **Æschylus: Prometheus Vincſtus: The Prometheus Bound**. From the Text of DINDORF. Edited, with English Notes, Critical and Explanatory, by the Rev. JAMES DAVIES, M.A. 1s.
32. **Æschylus: Septem Contra Thebes: The Seven against Thebes**. From the Text of DINDORF. Edited, with English Notes, Critical and Explanatory, by the Rev. JAMES DAVIES, M.A. 1s.
40. **Aristophanes: Acharnians**. Chiefly from the Text of C. H. WEISK. With Notes, by C. S. T. TOWNSEND, M.A. 1s. 6d.
41. **Thucydides: History of the Peloponnesian War**. Notes by H. YOUNG. Book 1. 1s. 6d.
42. **Xenophon's Panegyric on Agesilaus**. Notes and Introduction by L. F. W. JEWITT. 1s. 6d.
43. **Demosthenes. The Oration on the Crown and the Philippics**. With English Notes. By Rev. T. H. L. LEARY, D.C.L., formerly Scholar of Brasenose College, Oxford. 1s. 6d.



RETURN CIRCULATION DEPARTMENT
TO → 202 Main Library

LOAN PERIOD 1

HOME USE

4

5

NRLF

ALL BOOKS MAY BE RECALLED AFTER 7 DAYS

Renewals and Recharges may be made 4 days prior to the due date.

Books may be Renewed by calling 642-3405.

DUE AS STAMPED BELOW

SENT ON ILL

OCT 11 1995

U. C. BERKELEY

FORM NO. DD6

UNIVERSITY OF CALIFORNIA, BERKELEY
BERKELEY, CA 94720

YC 68564

M304871

TN 767
E5

THE UNIVERSITY OF CALIFORNIA LIBRARY

